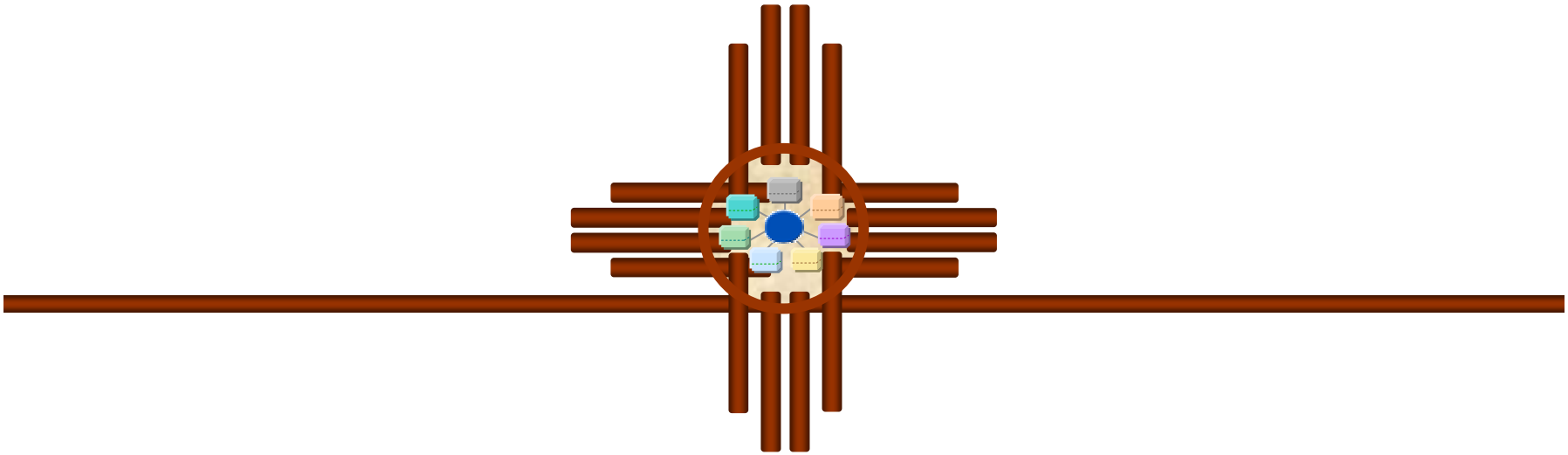
Using a Combination of UML, C2RM, XML, and Metadata Registries to Support Long-Term Development/Engineering



Open Forum 2003 on Metadata Registries

Knowledge Management and Learning Technologies Track
10:30 – Noon, 23 January 2003

Author: Dr. Israel Mayk, CERDEC

Co-authors: MAJ (IDF) Avi Yariv (IDF/CERDEC ESEP) and Bernard Goren (CERDEC)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JAN 2003		**00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Using a Combination of UML, C2RM, XML, and Metadata Registries to Support Long-Term Development/Engineering	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Communications-Electronics RD&E Center,Fort Monmouth,NJ,07703**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**69**	

Objective

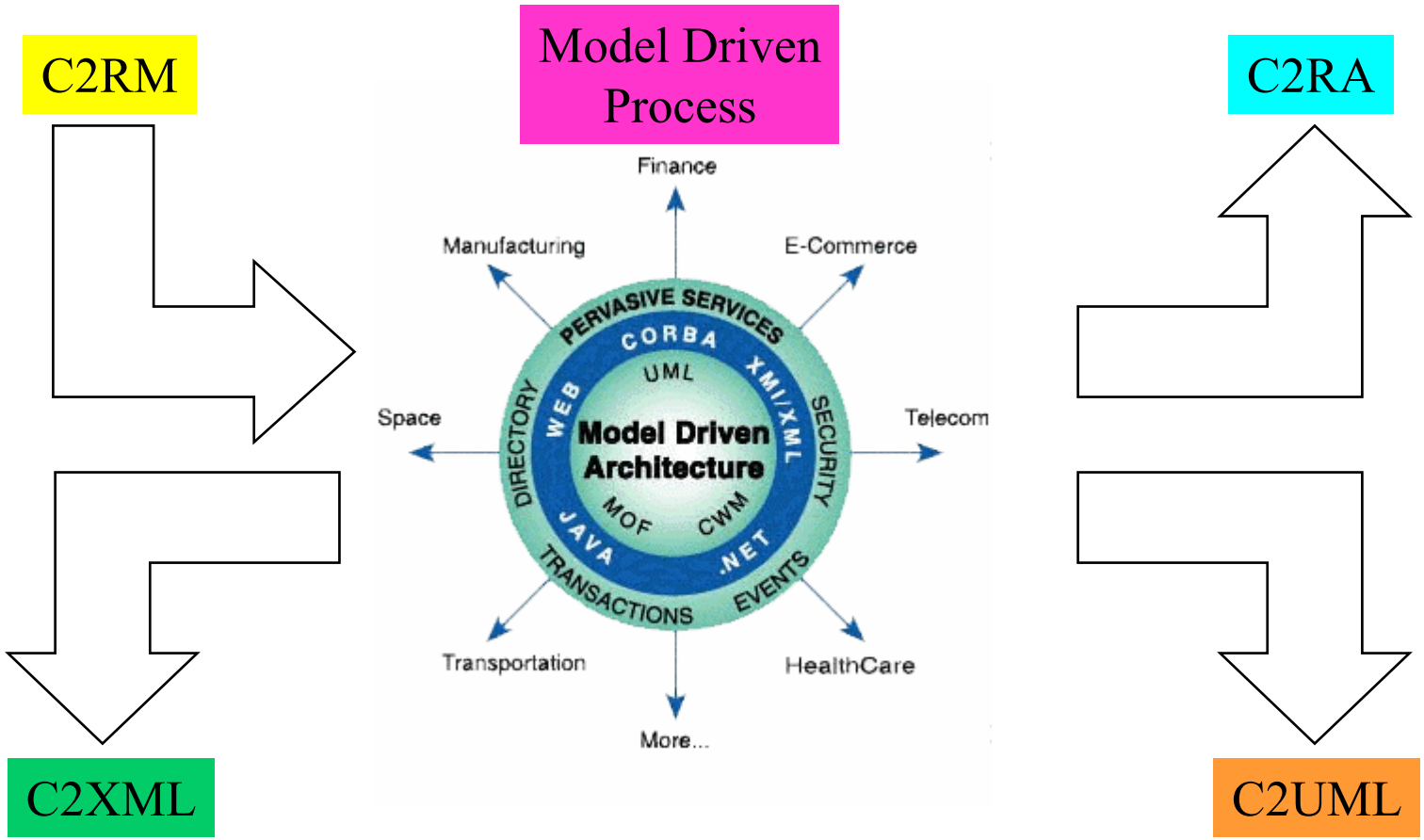
- **To facilitate C2 Architecture and Applications development in terms of a formal language for C2 based upon a C2RM**
- **To derive the rules for analyzing and parsing C2 Products from Natural Language to Machine Language for use by C2 Applications.**
- **To leverage commercial representation and modeling languages such as the Unified Modeling Language (UML) and Extensible Markup Language (XML and associated tools.**

Why Reference Models

- **" By creating compelling reference models of (domain) knowledge, we lead our organizations into the appropriate conclusions."**
- **"Reference models are the patterns of the solution for transforming perception into real-world success."**
- **"Reference models simplify problem solving, so that ordinary professionals can practice their discipline with world-class results"**
- **"Software professionals need reference models in order to understand abstractions"**
- **"20% of adults have the appropriate world-perspective to define abstractions."**
- **"Reference models (and reference architectures) are necessity in the confusing, rapidly changing technology environment in which we practice"**
- **"Reference models are commonplace in fields of human endeavor"**

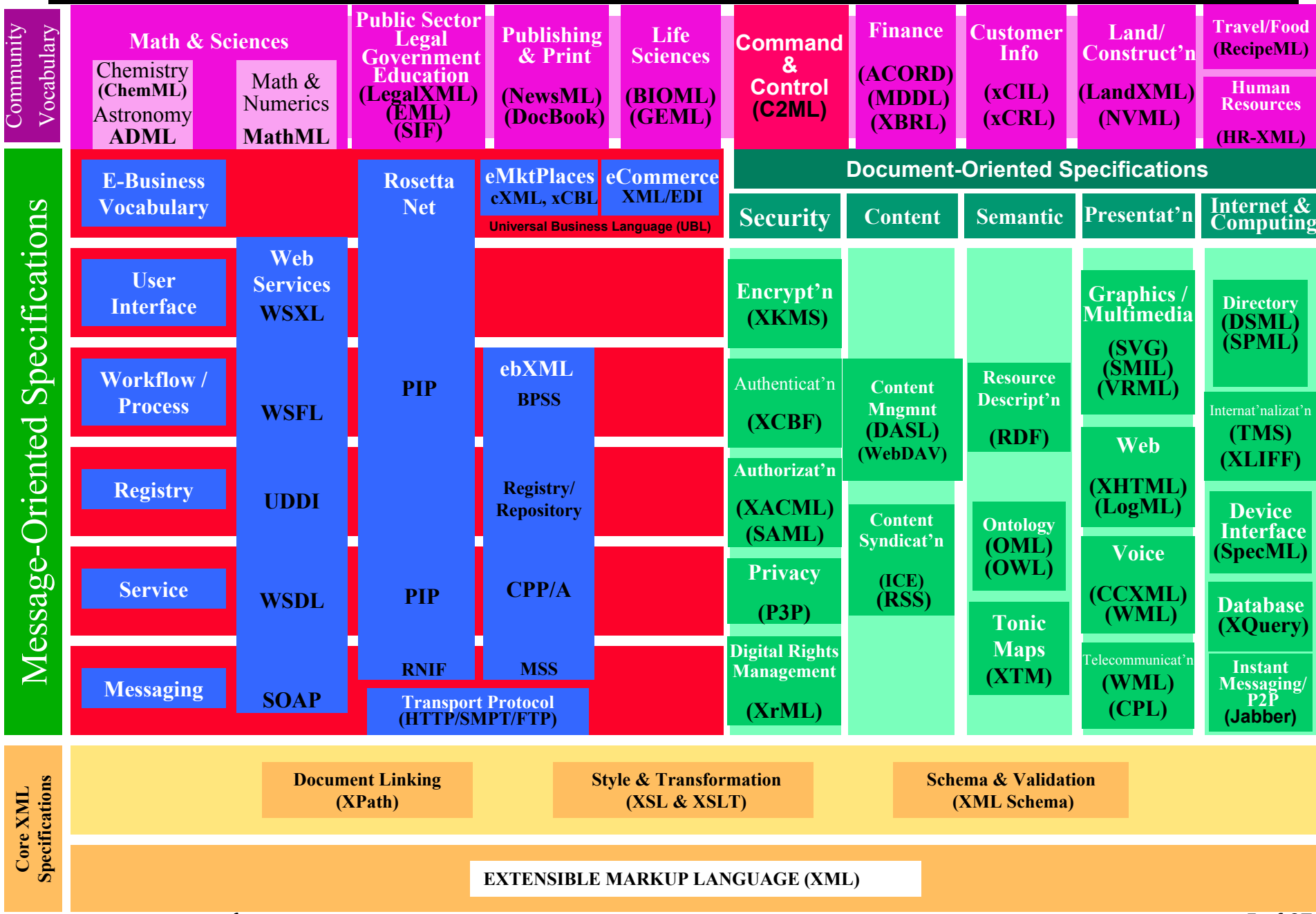
See Software Architect Bootcamp, Raphael Malveau and Thomas J. Mowbray, Prentice Hall, 2001, p.238-239

Relationship of C2UML to C2RM C2RA, and C2XML



KEY XML SPECIFICATIONS AND STANDARDS

Adapted from Zapthink

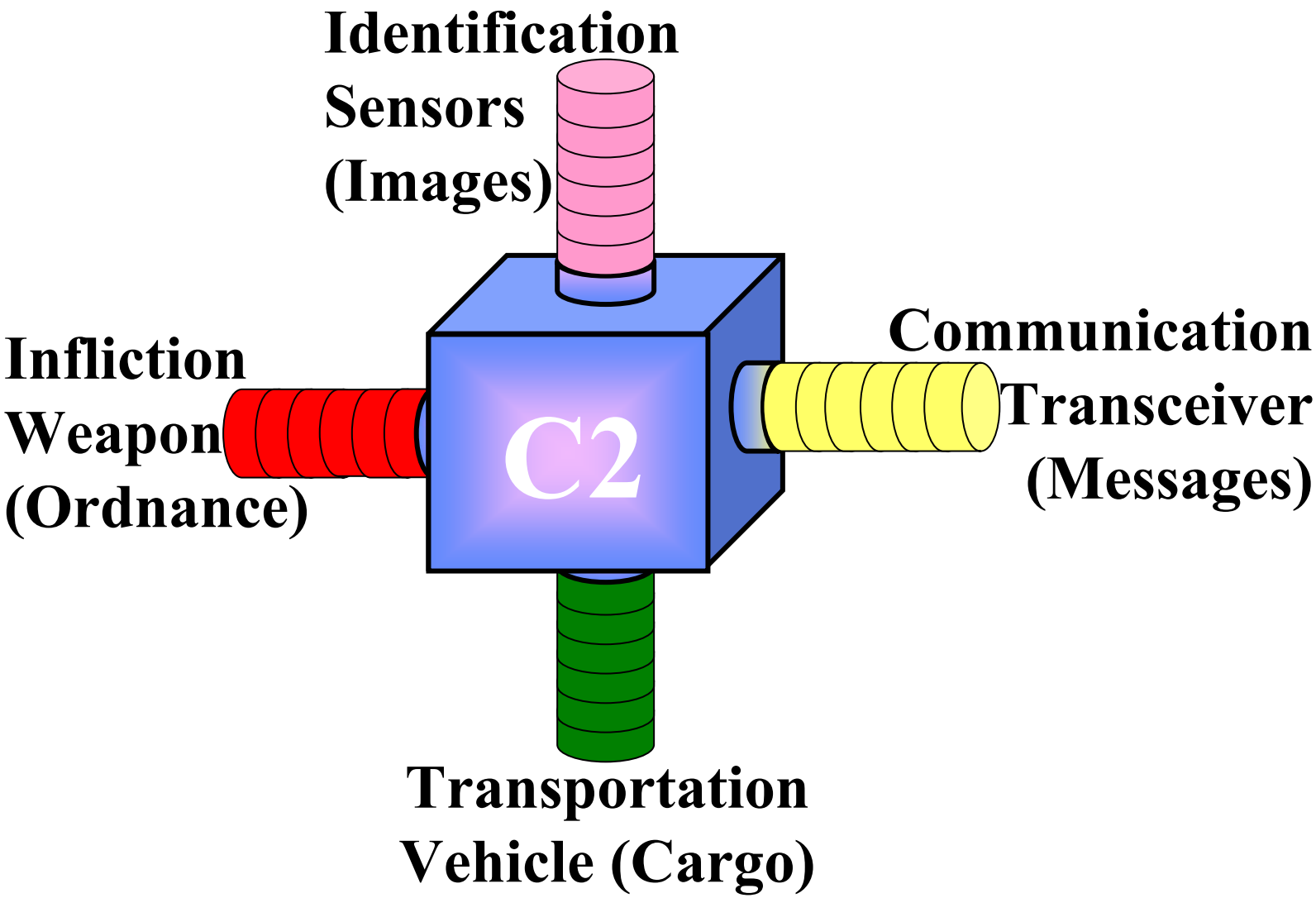


C2 Product Example: Operations Order (OPORD)

Five-Paragraph Meta-model based upon
FM 101-5, Staff Organization and Operations

- Situation
  - The Enemy Forces
    - Who are they? What kind of unit is it? What kind of Equipment do they have?
    - Where are they? How strong are they? Where are they effective?
    - How capable are they? What are they likely to do?
  - The Friendly Forces
    - What is our higher echelon mission and Concept of Operation? What is the mission of adjacent units?
- Mission
  - A clear concise, statement of what the unit is to do to include who,where, when, and why of the operation.
- Execution
  - What is the Concept of Operation? How to maneuver, how to fire, how to deal with obstacles? In Offense: what unit formations, movement techniques, routes of advance? On Defense: what battle positions to establish, weapon orientation, engagement plan, +more.
- Service Support
  - Where is refueling, How? Where is the collection point of damaged vehicles?
- Command and Signal
  - How communications will be maintained?
  - What is the command succession?

C2RM Generic Entity



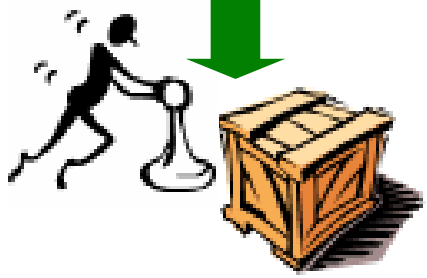
C2RM Generic Package Classes

Image
Photons, Sounds, Scent, Touch, Electromagnetic, Radiation

Message
Voice, Text, Alert, Electronic

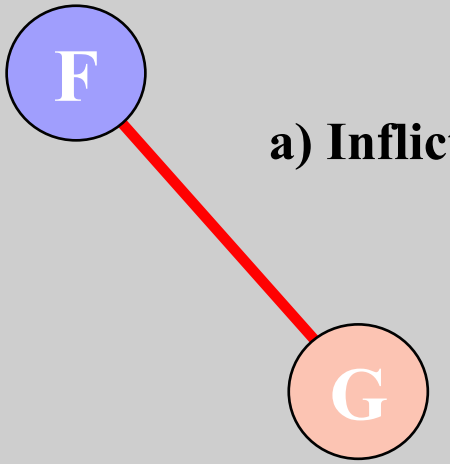
Sensor | Wpn | C2 | Tcvr | Tcvr | C2 | Sensor | Wpn | Vehicle | Vehicle

Ordnance
Bombs, Bullets, Shells, Missiles, Photons, Gas, Water, Stones

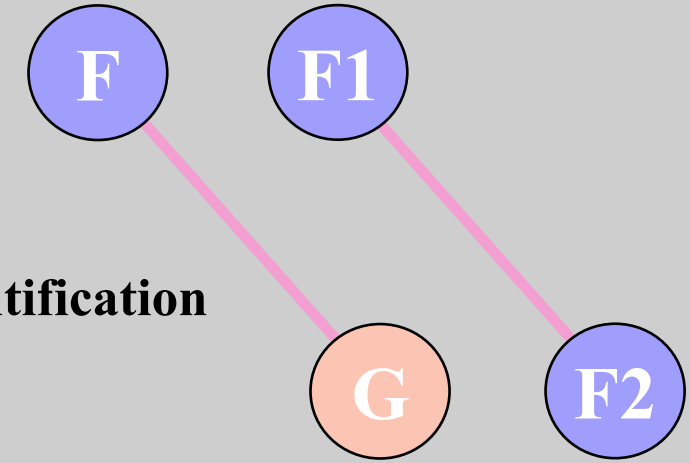


Cargo
Crate,Pallet, Own Weight, Supply, Stowage

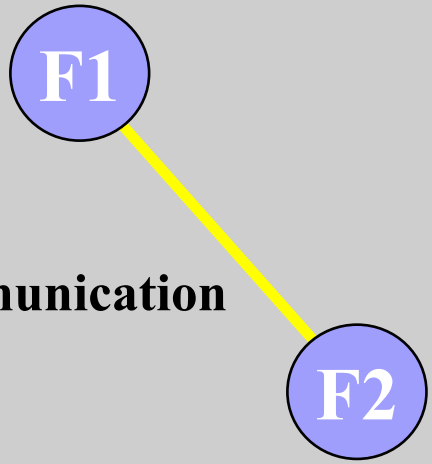
Fundamental types of Interactions



a) Infliction/Effects

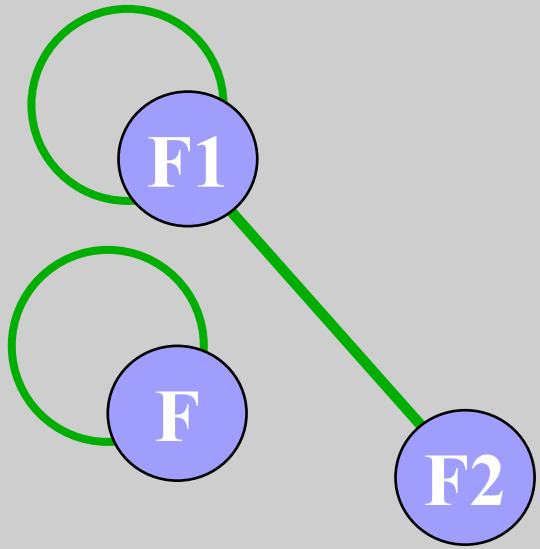


b) Identification



c) Communication

d) Transportation



Legend:

Resource

Friend F

Foe G

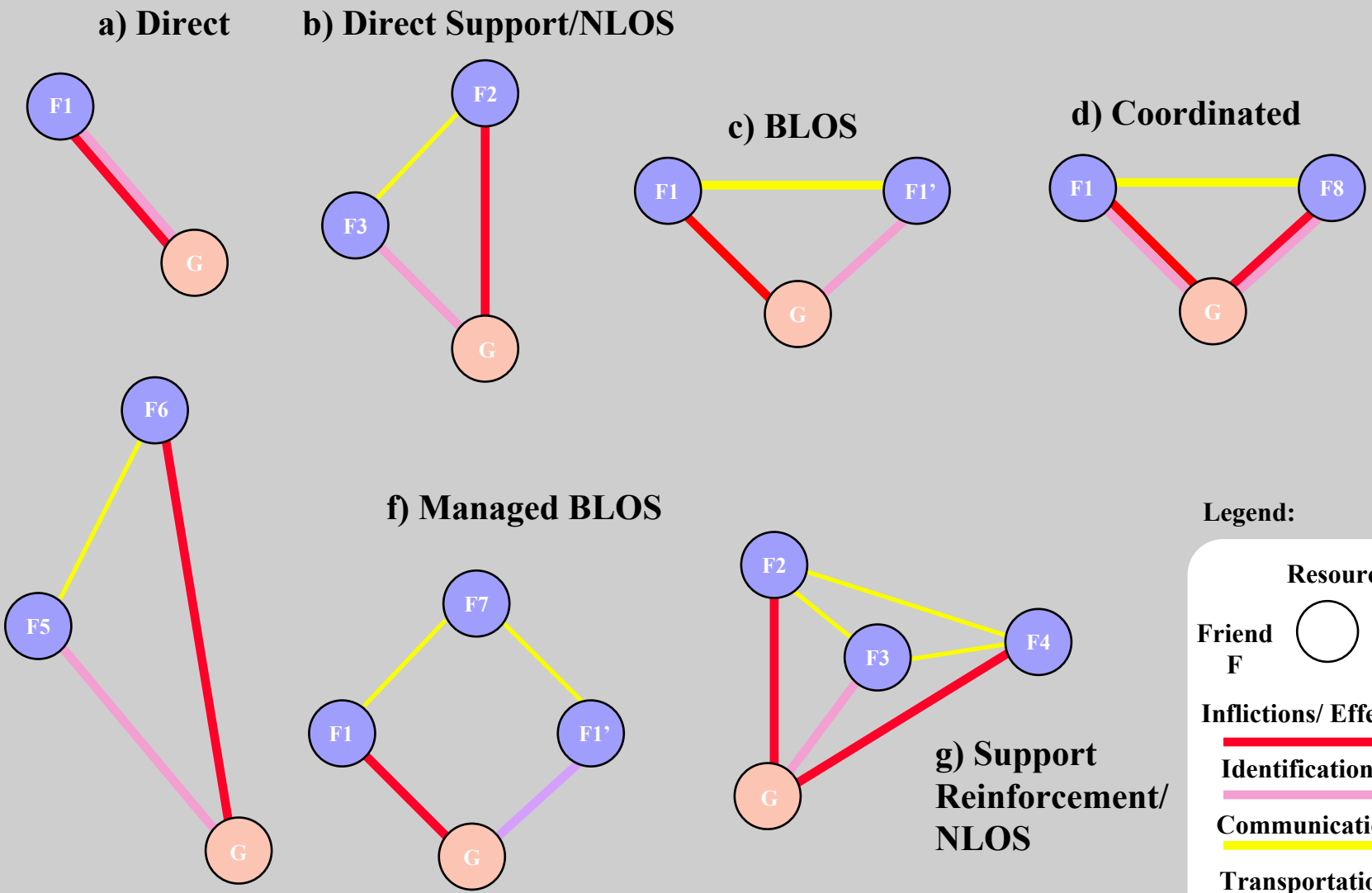
Inflictions/effects

Identifications

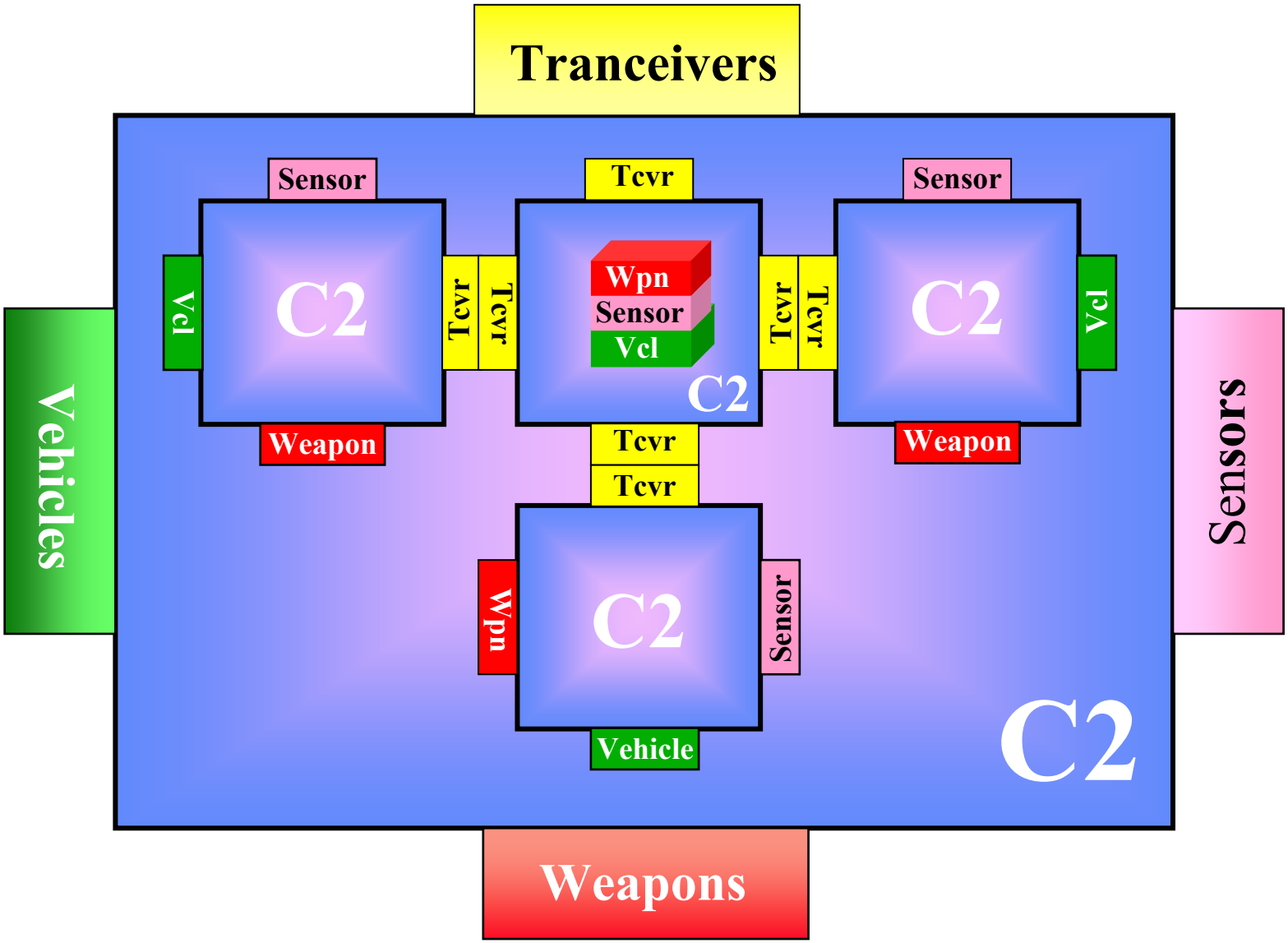
Communications

Transportations

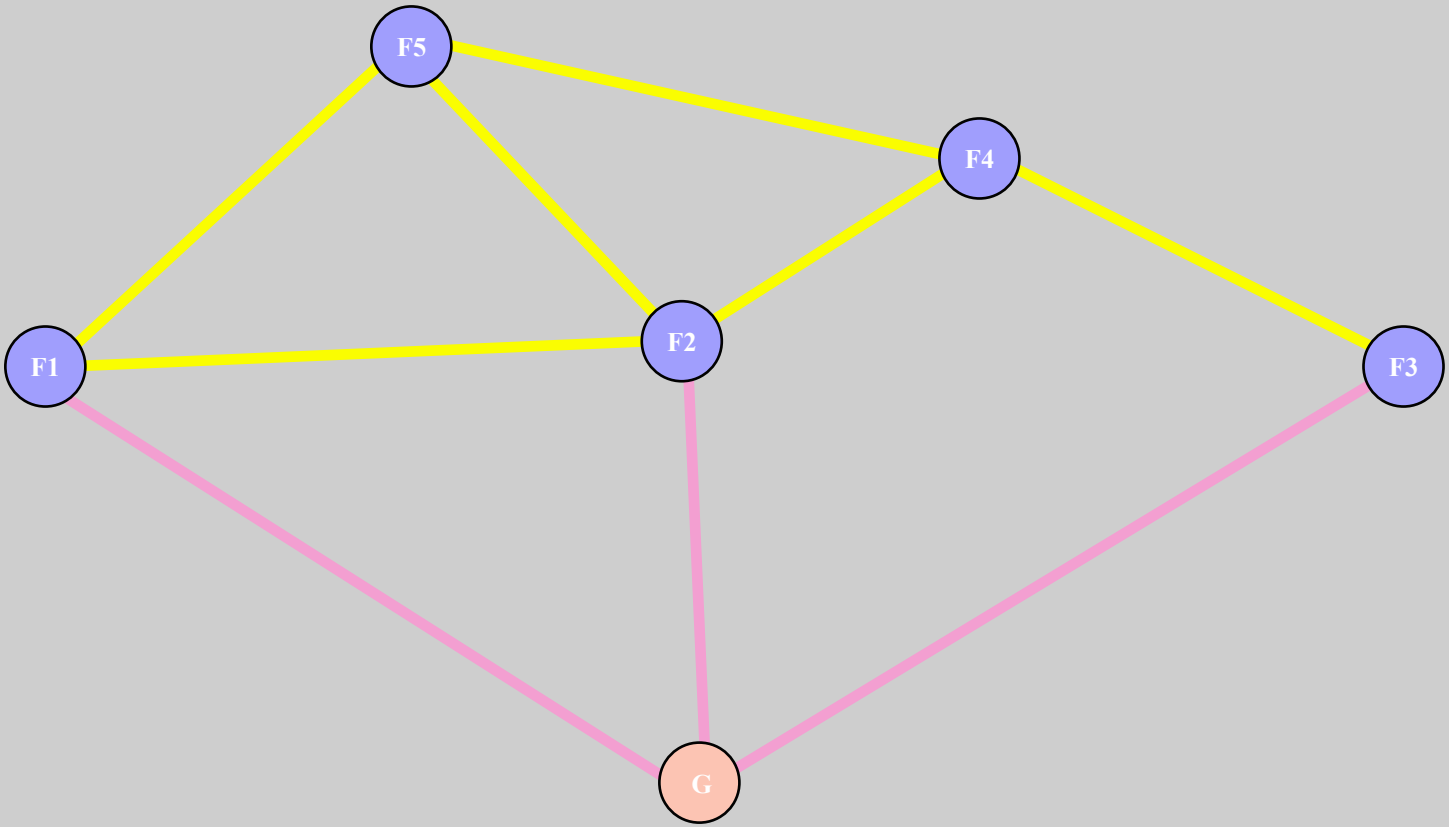
F27. Fundamental types of engagements



Nested/Aggregated C2RM Entities



Network-Centric Sensors



Legend:

Resource

Friend F **Foe G**

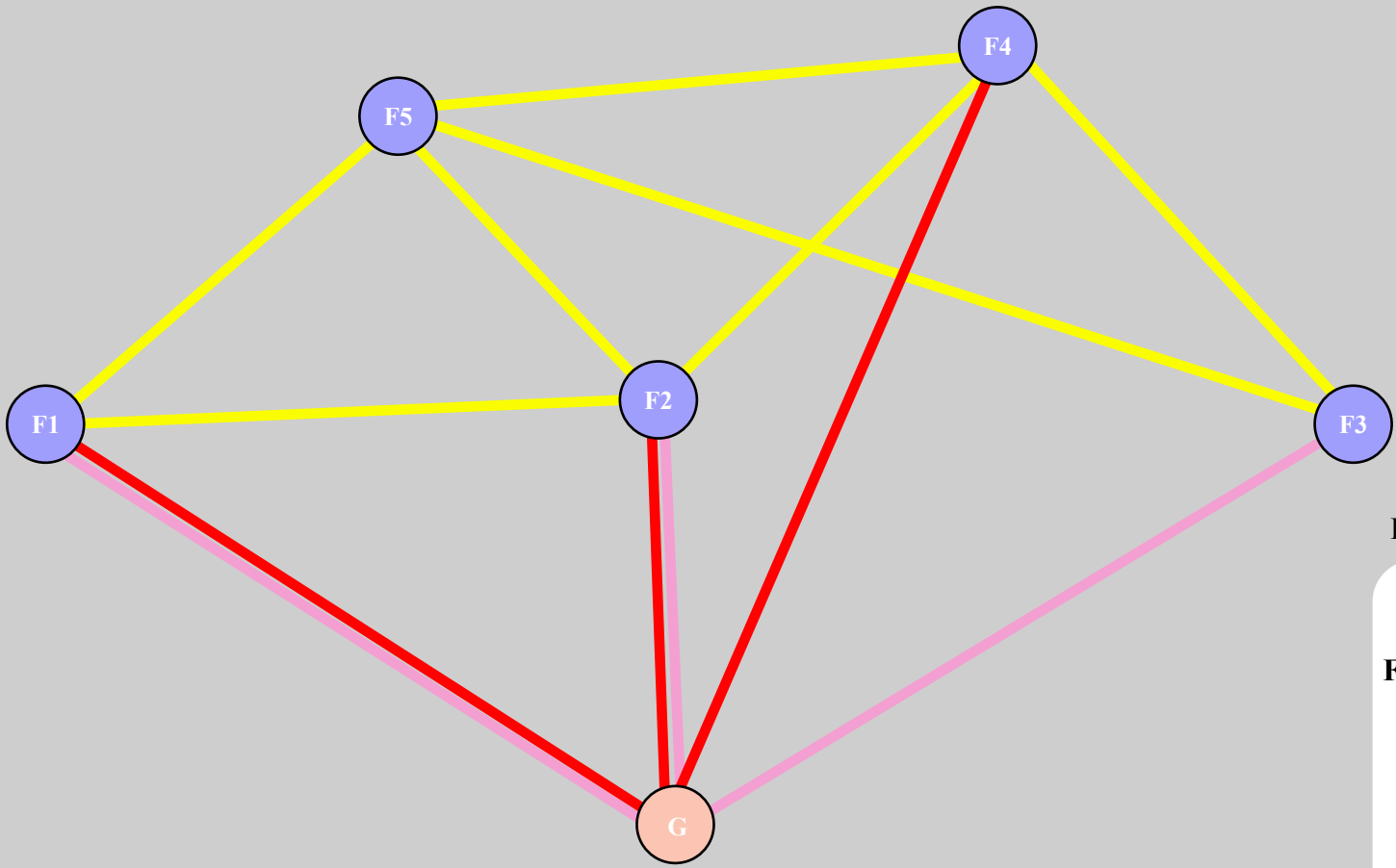
Inflictions/Effects

Identifications

Communications

Transportations

Network-Centric Fire



Legend:

Resource

Friend F — Foe G

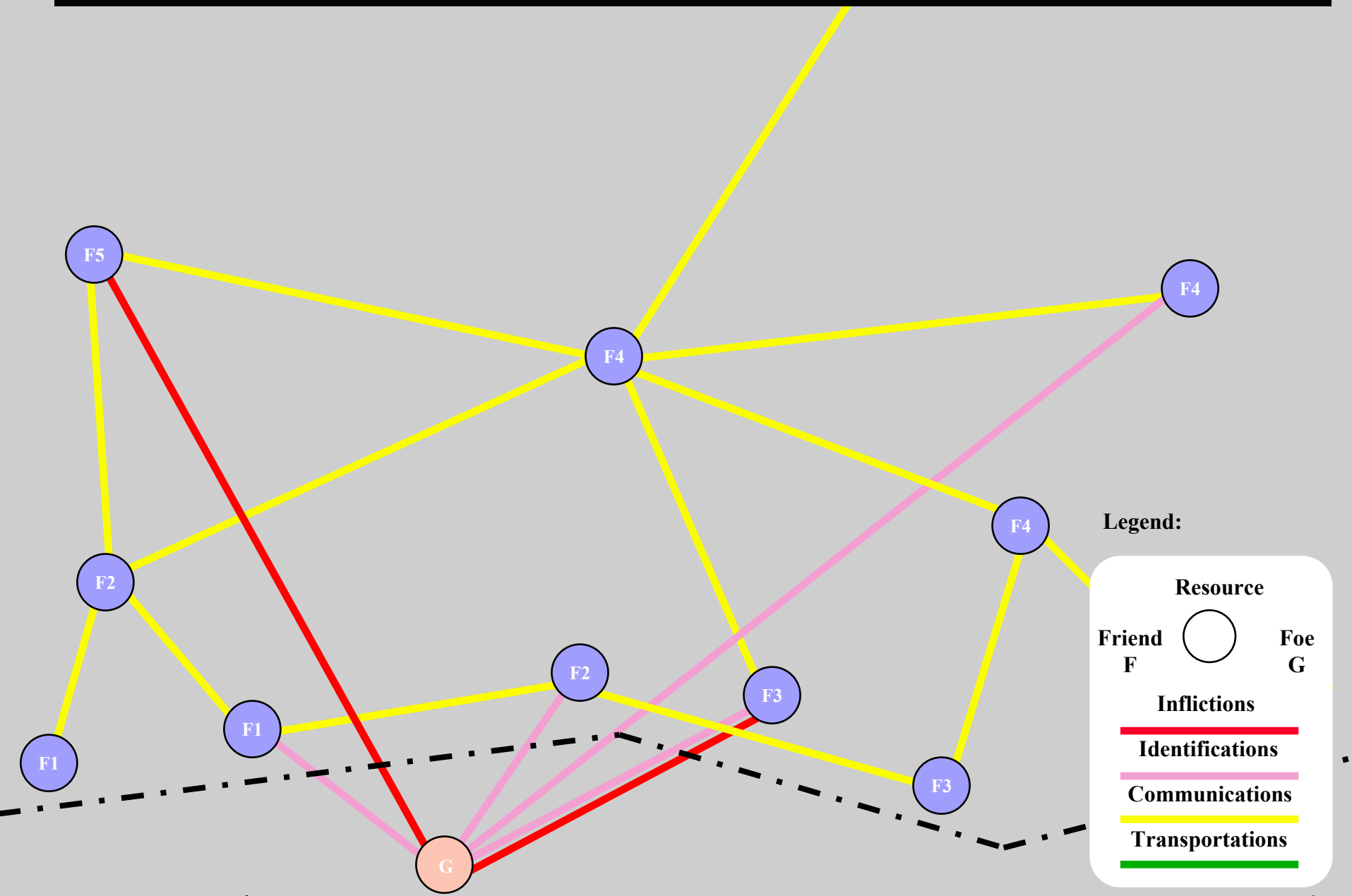
Inflictions

Identifications

Communications

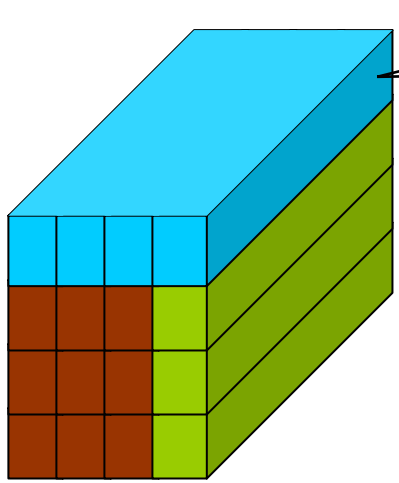
Transportations

Network-Centric Border



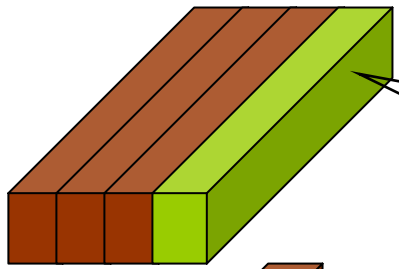
Building a Reference Force

Crew / Team



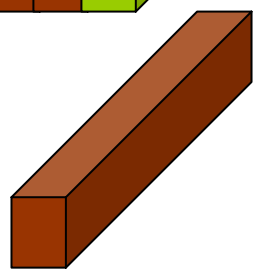
Crew / Team
C2, CS

Sec / Sqd

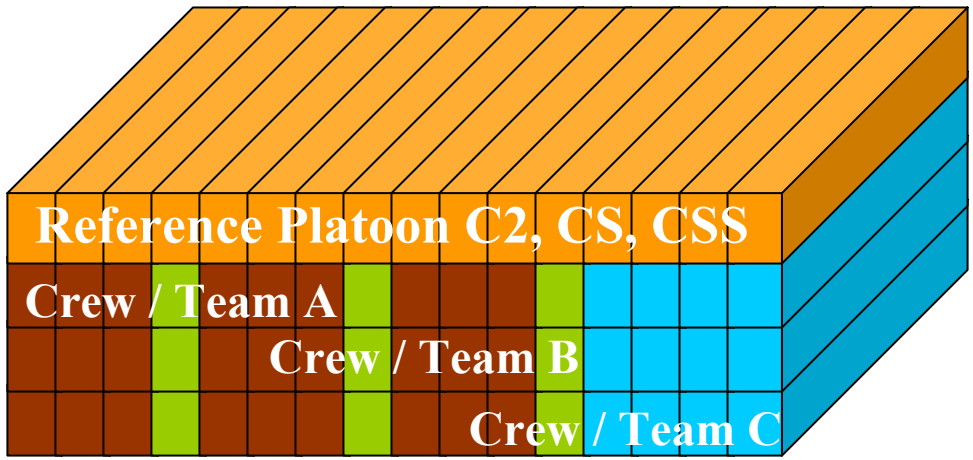


Sec / Sqd
C2 / CS

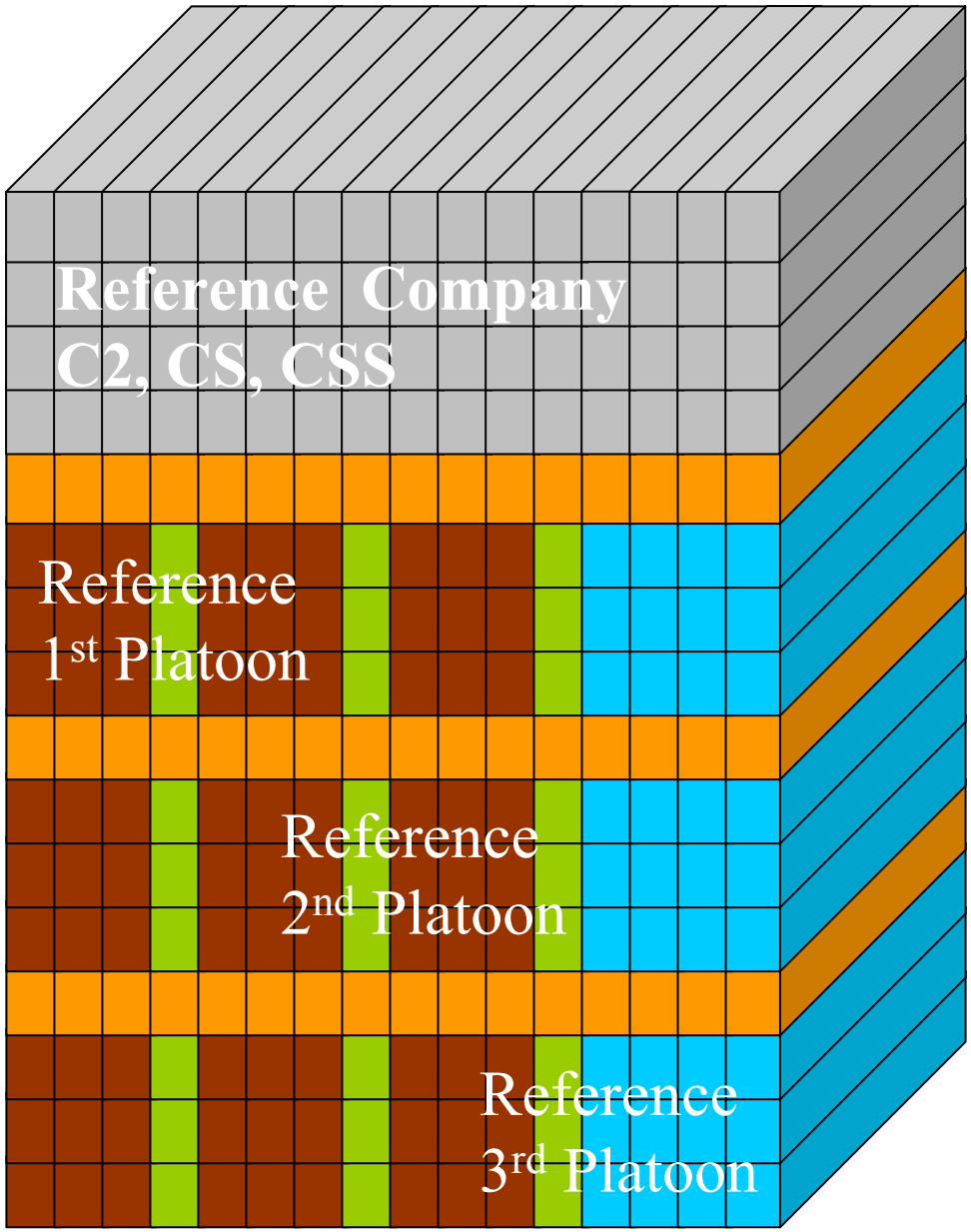
Individual



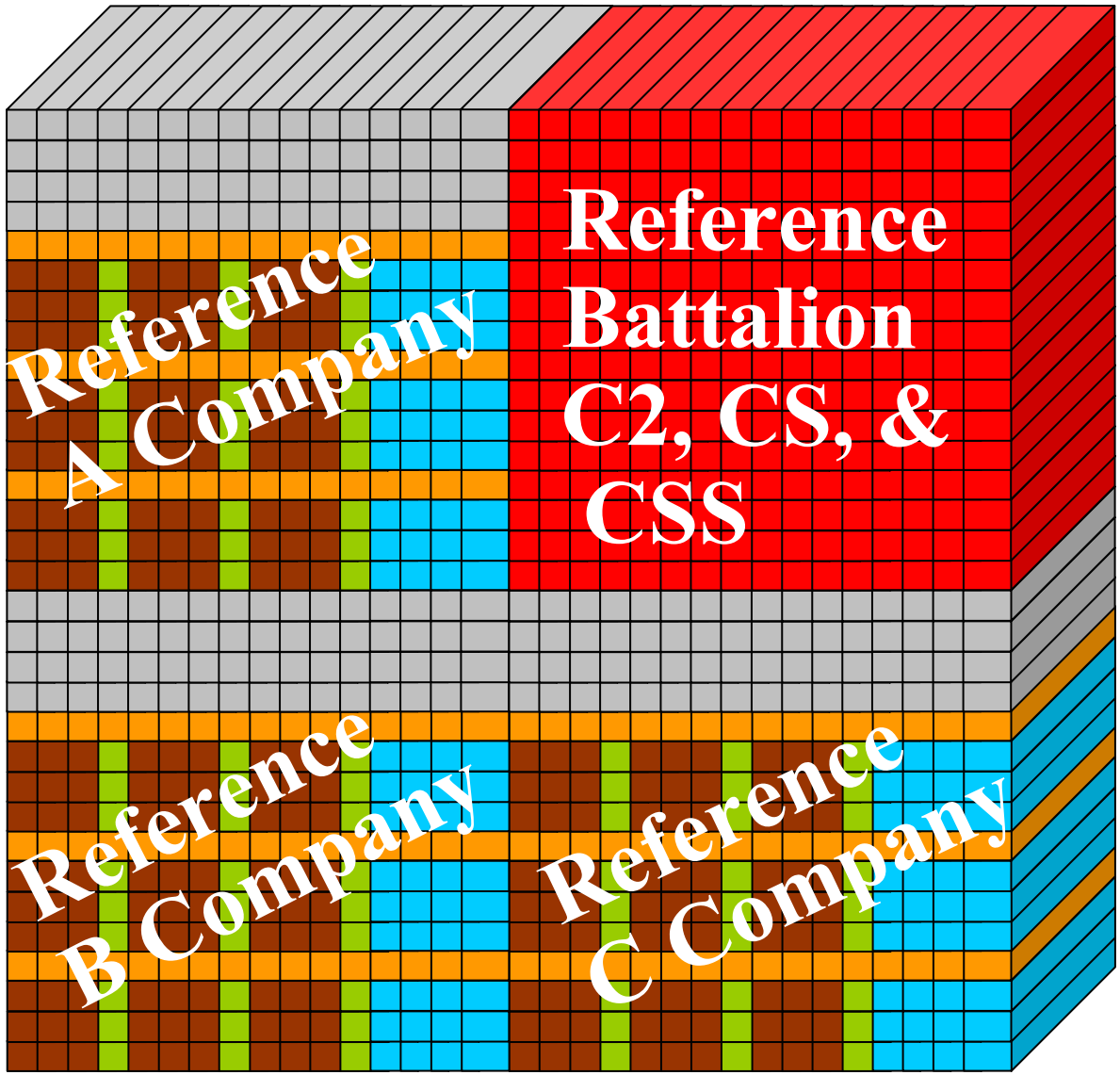
A Reference Platoon



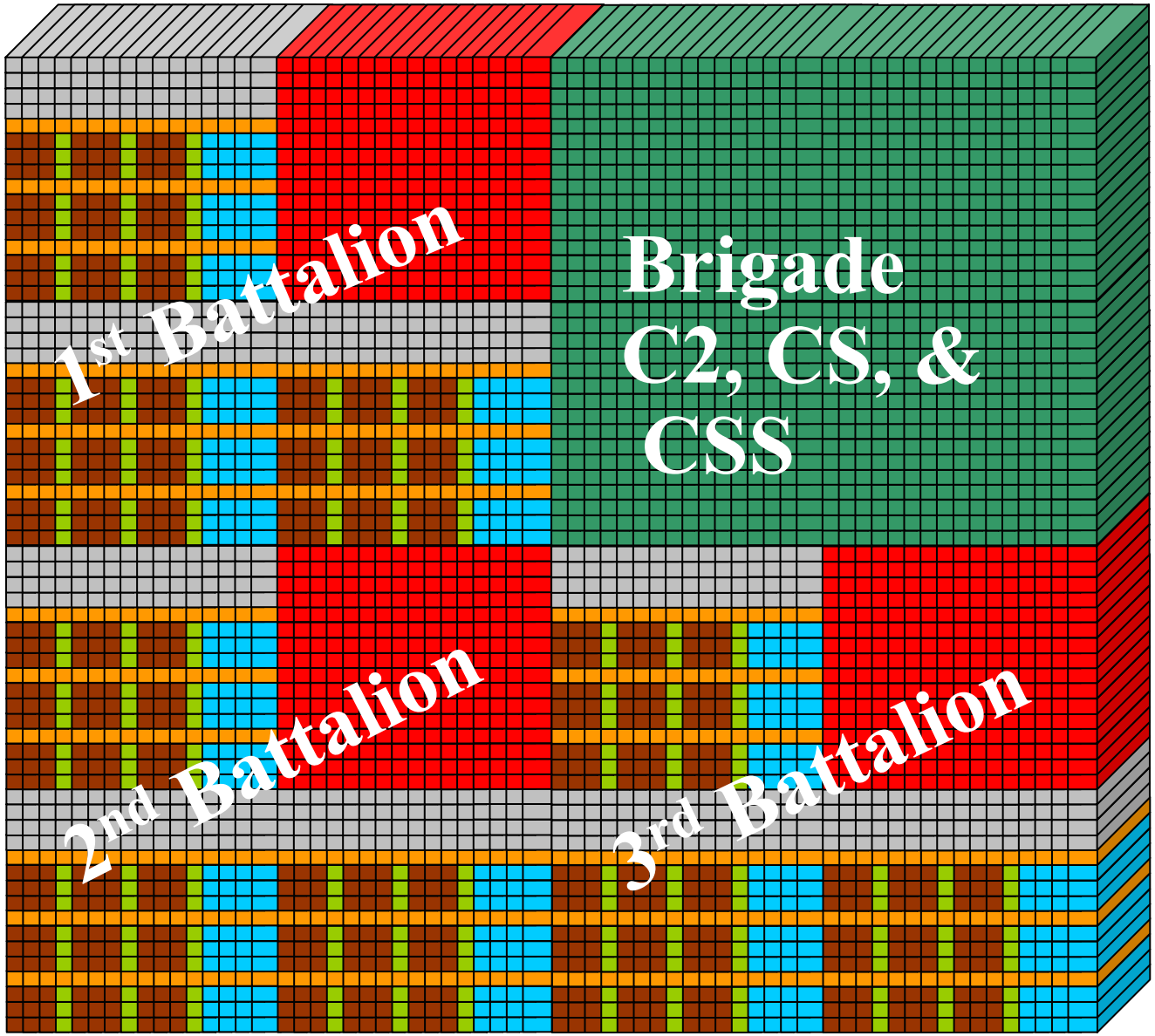
A Reference Company



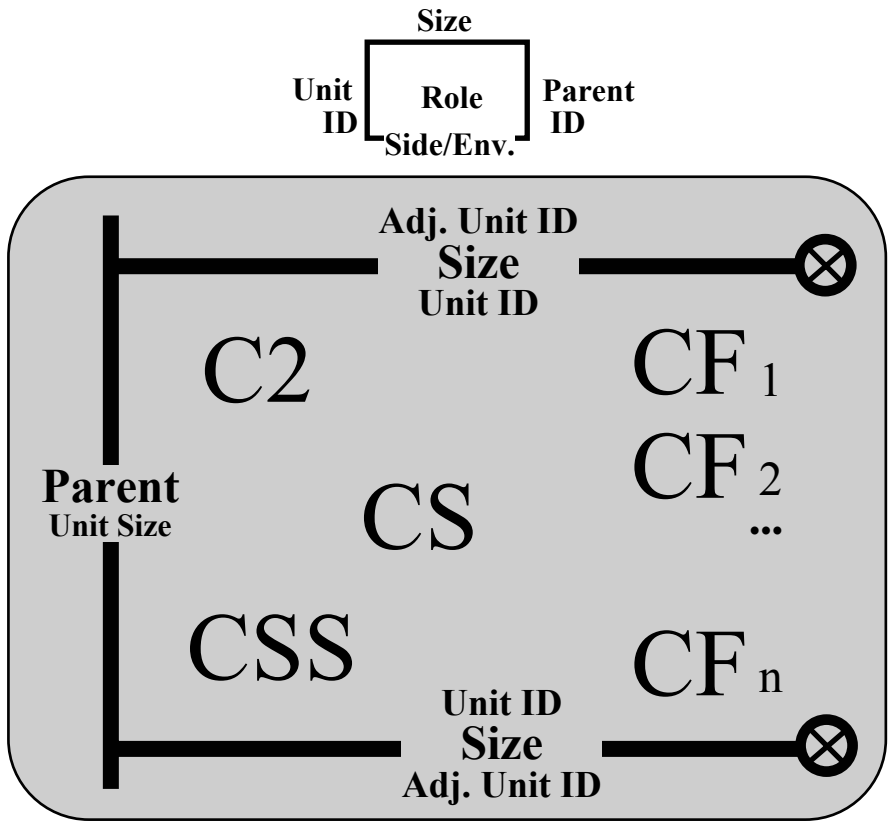
A Reference Battalion



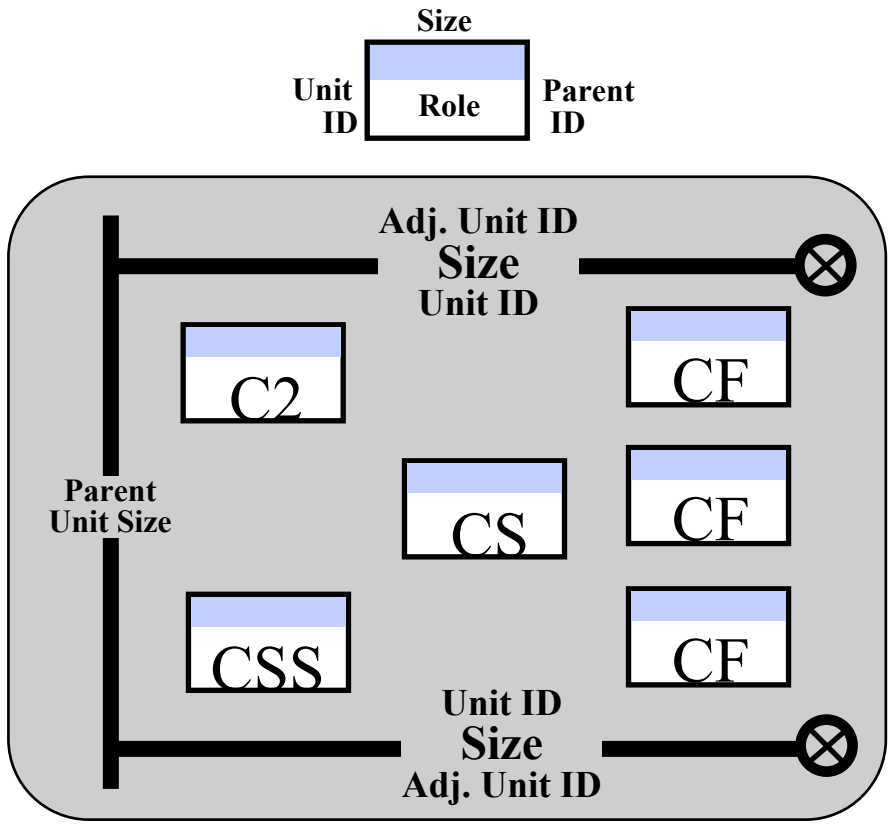
A Reference Brigade



Generic Unit Representation

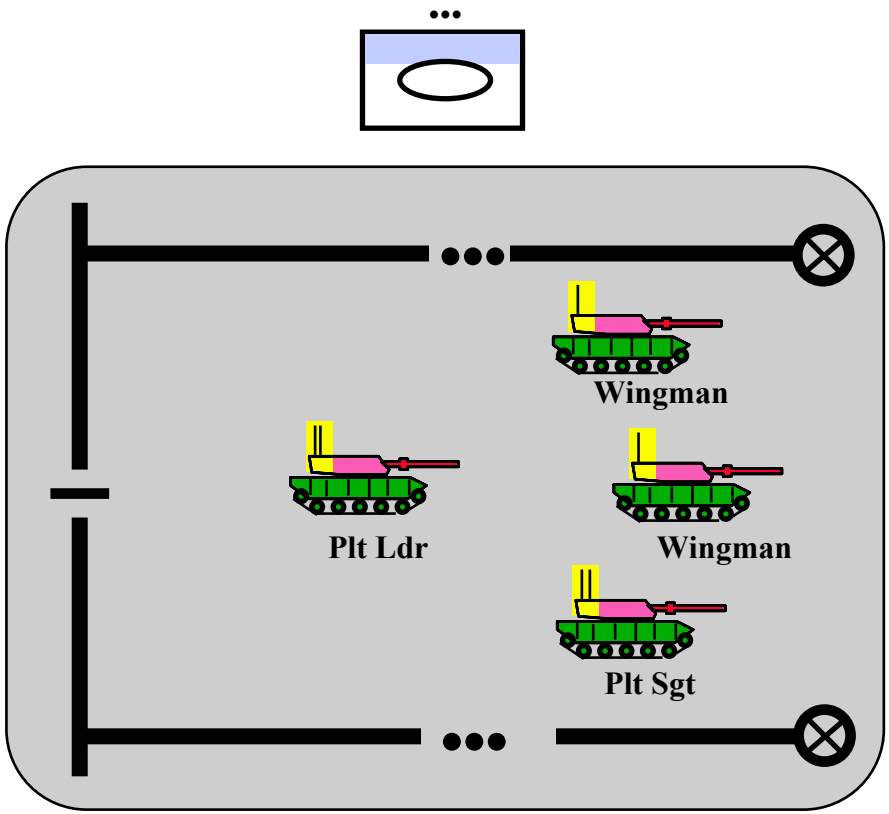


Ground Unit Representation



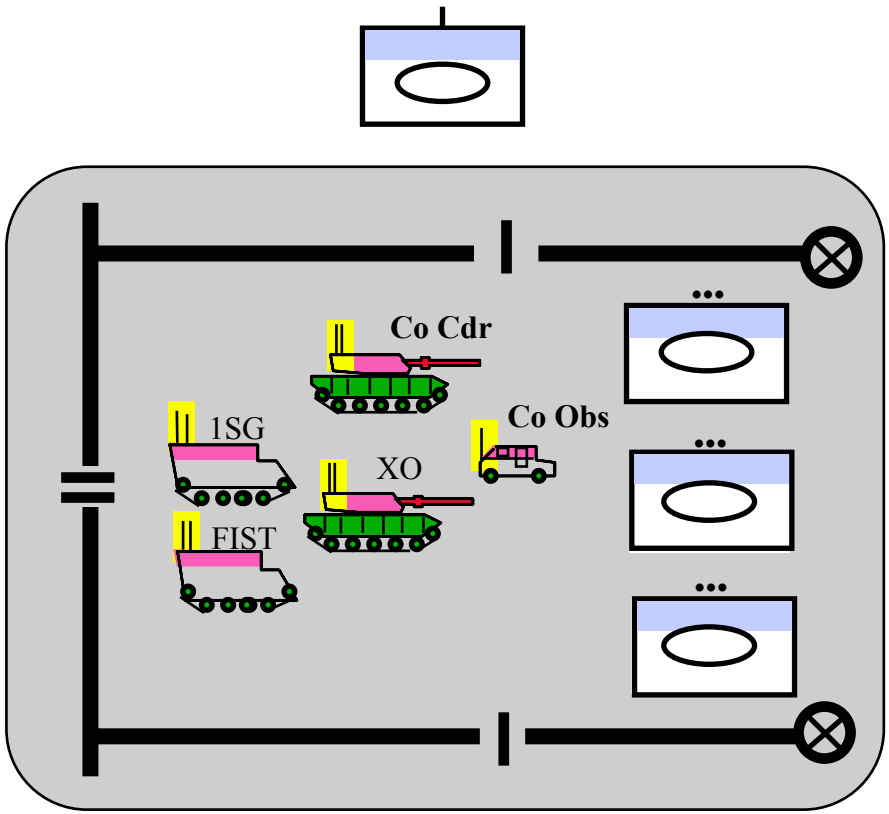
Armor Unit Representation

Platoon Example



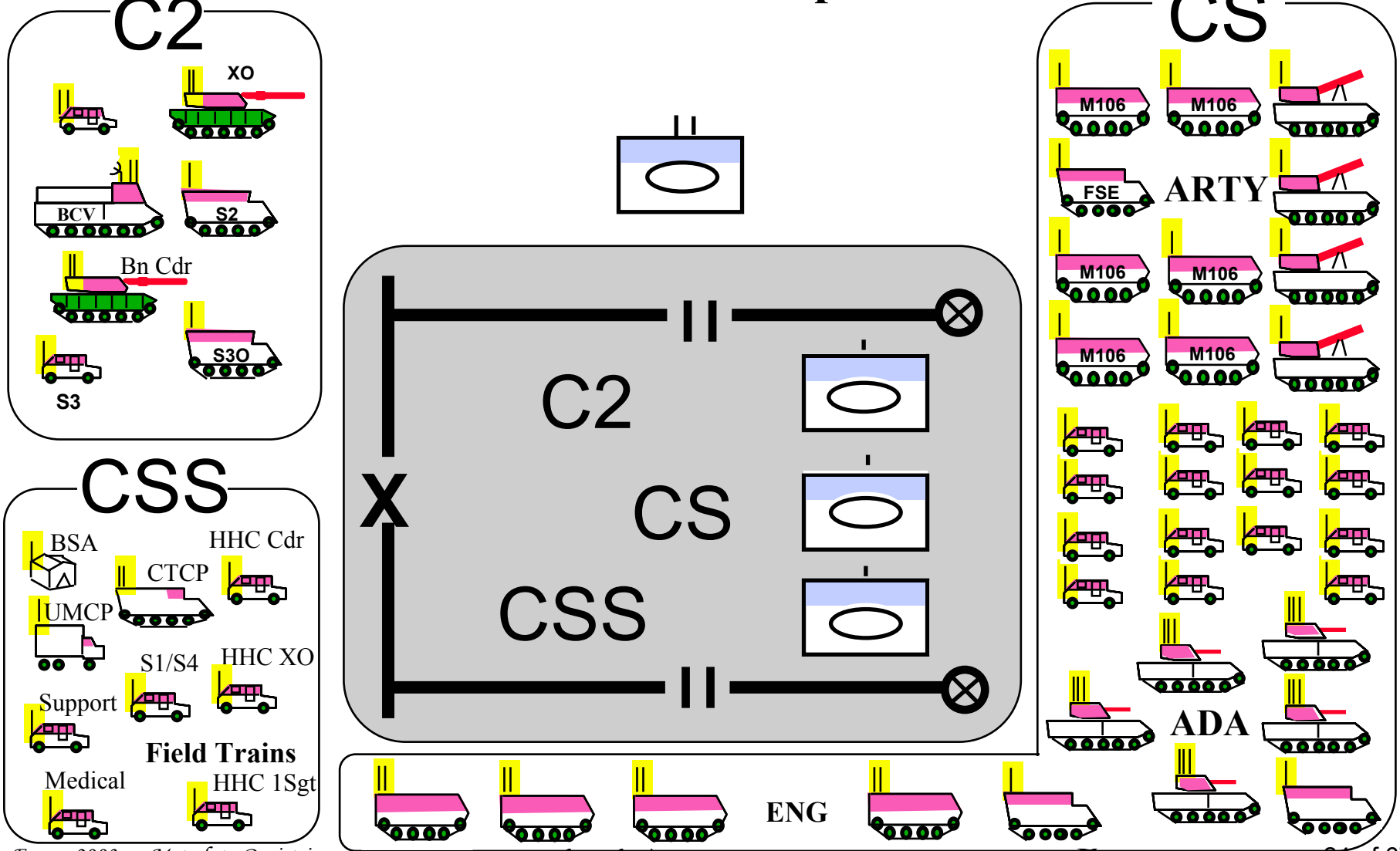
Armor Unit Representation

Company Example



Armor Unit Representation

Battalion Example



C2 Systems are like Onions

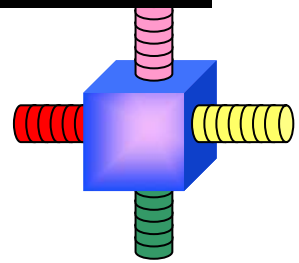
Onions have layers
Regardless of whether one likes them of not
C2 Systems also have layers

The world according to Shrek

Layers, therefore, are essential to describing onions
Similarly, Layered architectures are critical in representing C2 Systems

Every Port Consists of 7 Logical Layers

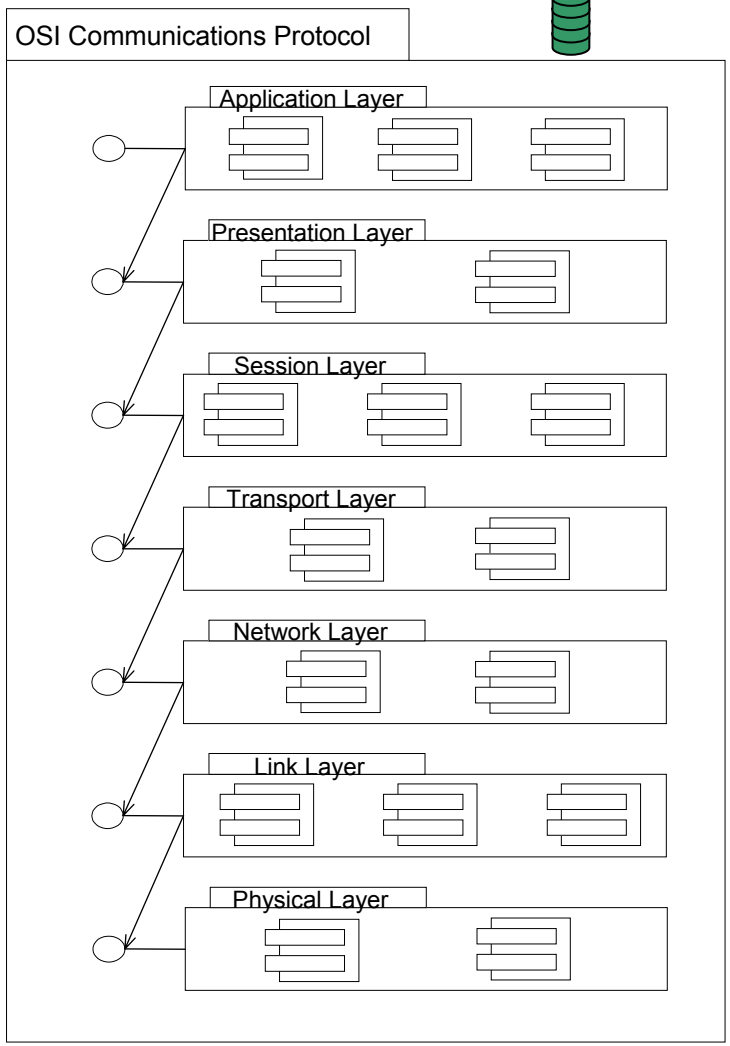
(According / Analogous to the OSI Communication Layer Model)



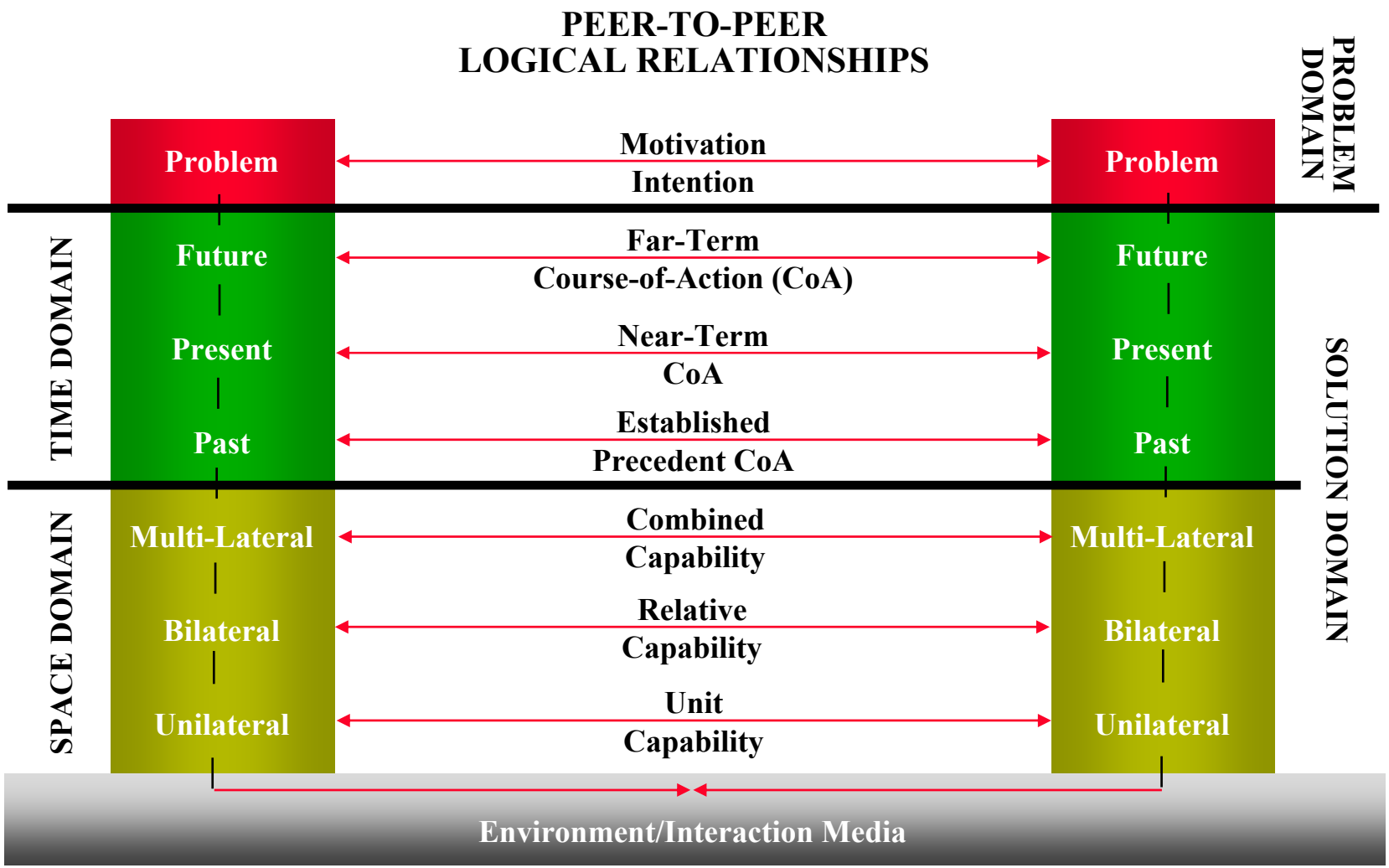
Example

The Communication Port includes the following layers :

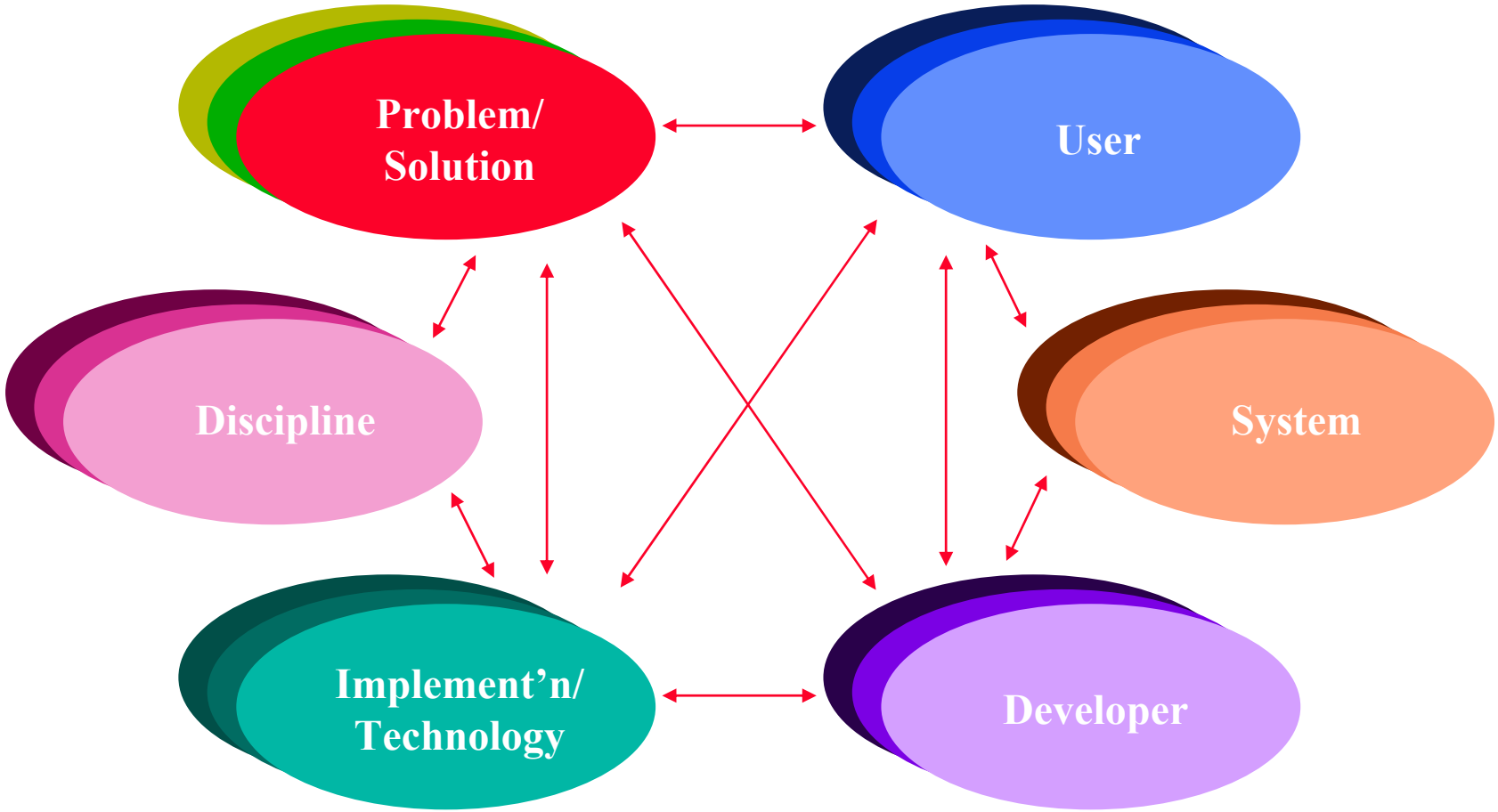
7. **Application Layer** – The GOAL of the C2 process enabled by the port.
6. **Presentation Layer** – translates formats between the port and the application.
5. **Session** – responsible for a complete sequence / dialog of actions necessary to complete a set of transactions.
4. **Transport** – a middle and supervising layer to provide transparency of the networking between any two port types/users.
3. **Network** – multi-connection between more than two assets of the same port type.
2. **Link** – single connection between two assets of the same port type.
1. **Physical** – the port's electrical and physical interface to the environment.



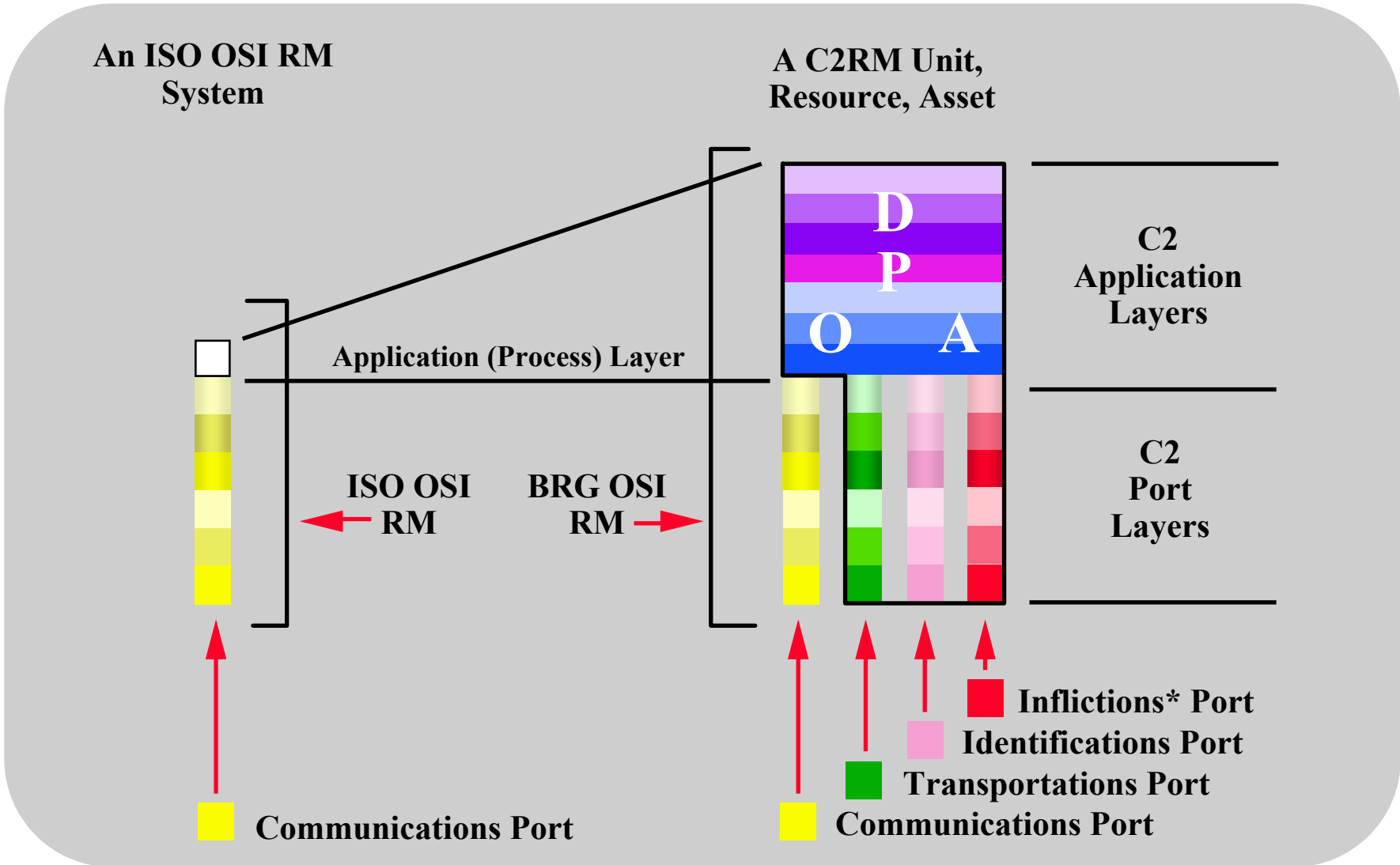
F6. Layering the Problem/Solution domain



F5. Domains for developing C2 objects

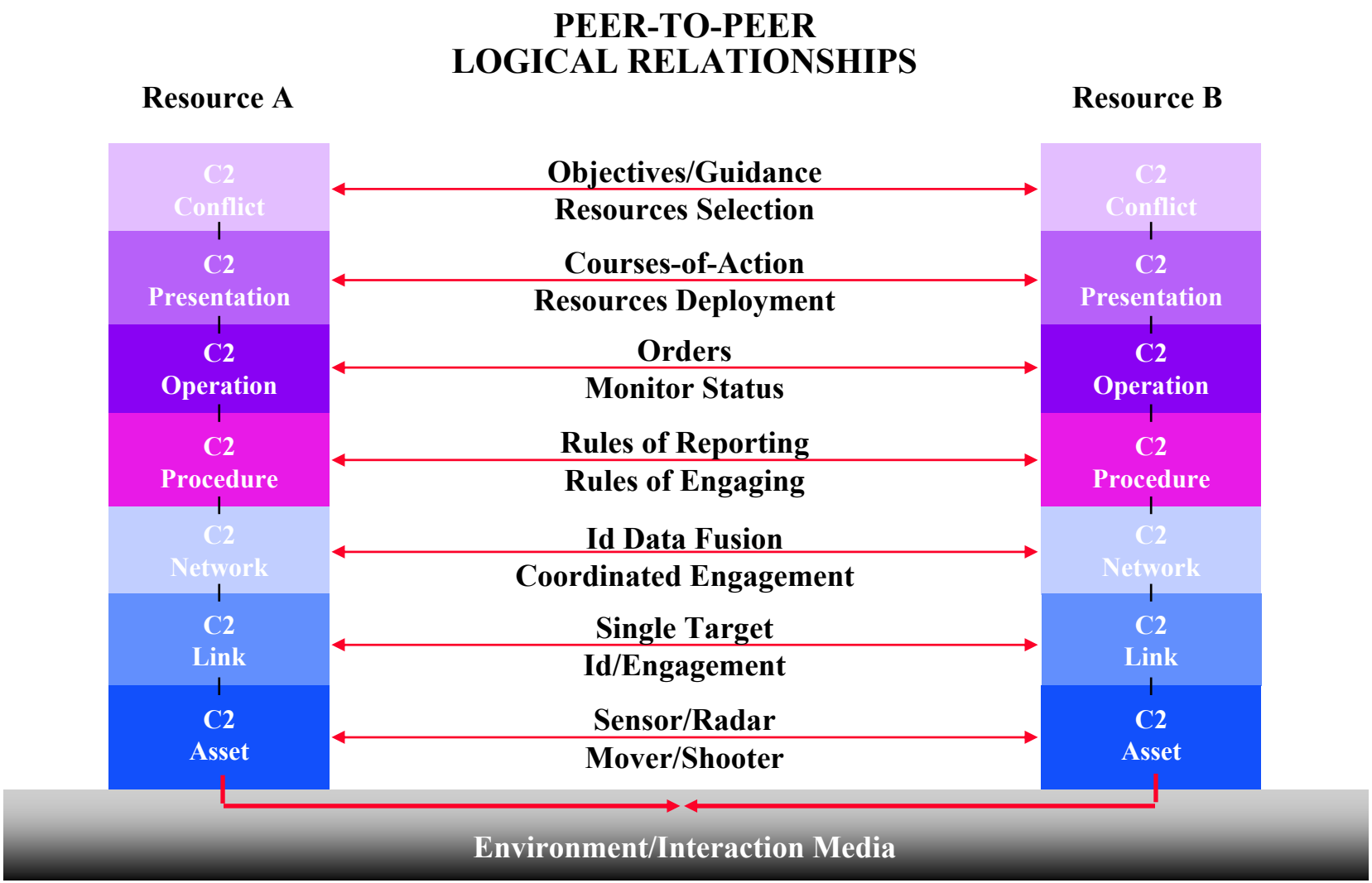


Extending the ISO OSI RM to C2

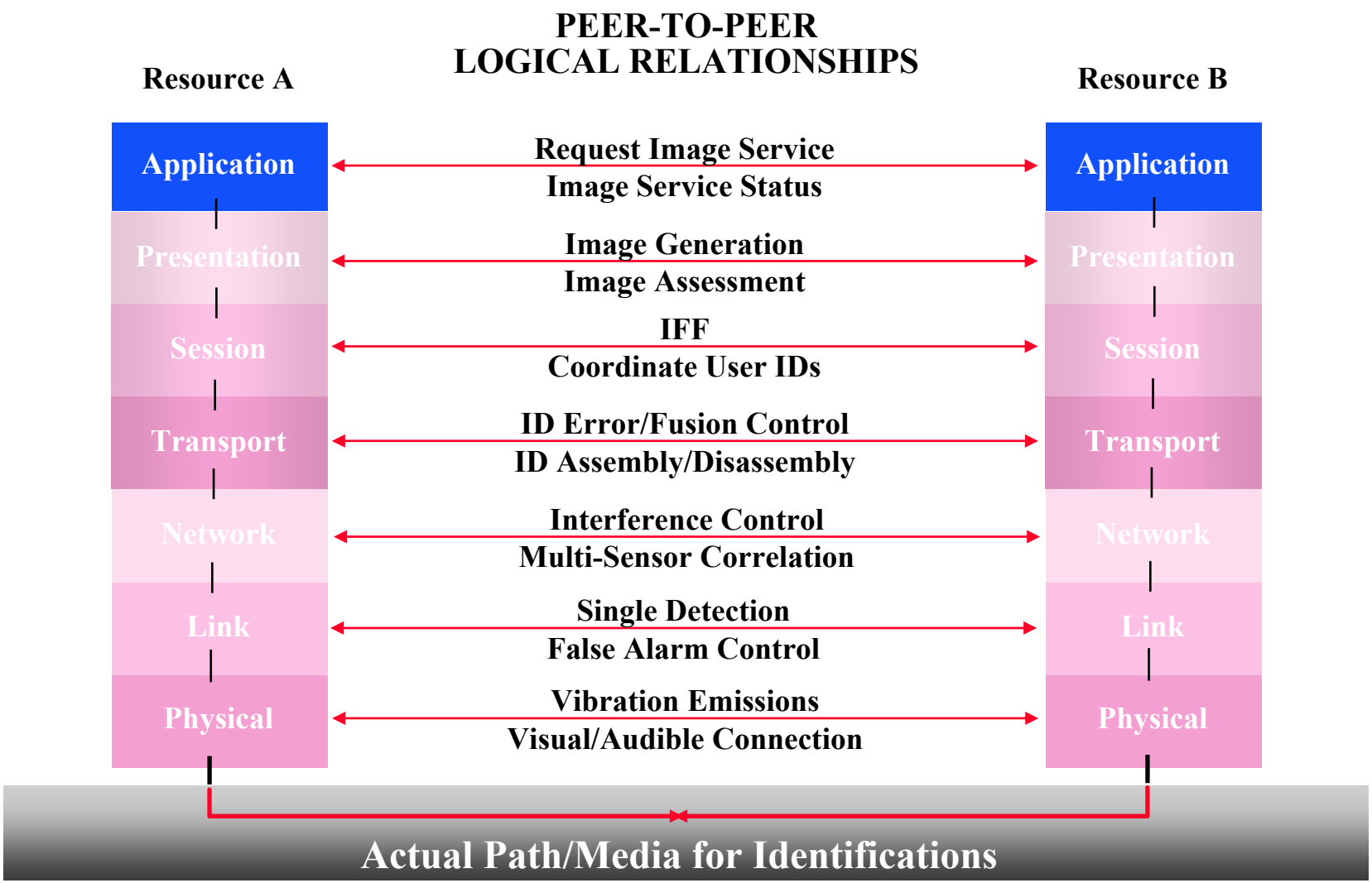


*Inflictions = Negative Effects / Impacts (lethal / non-lethal)

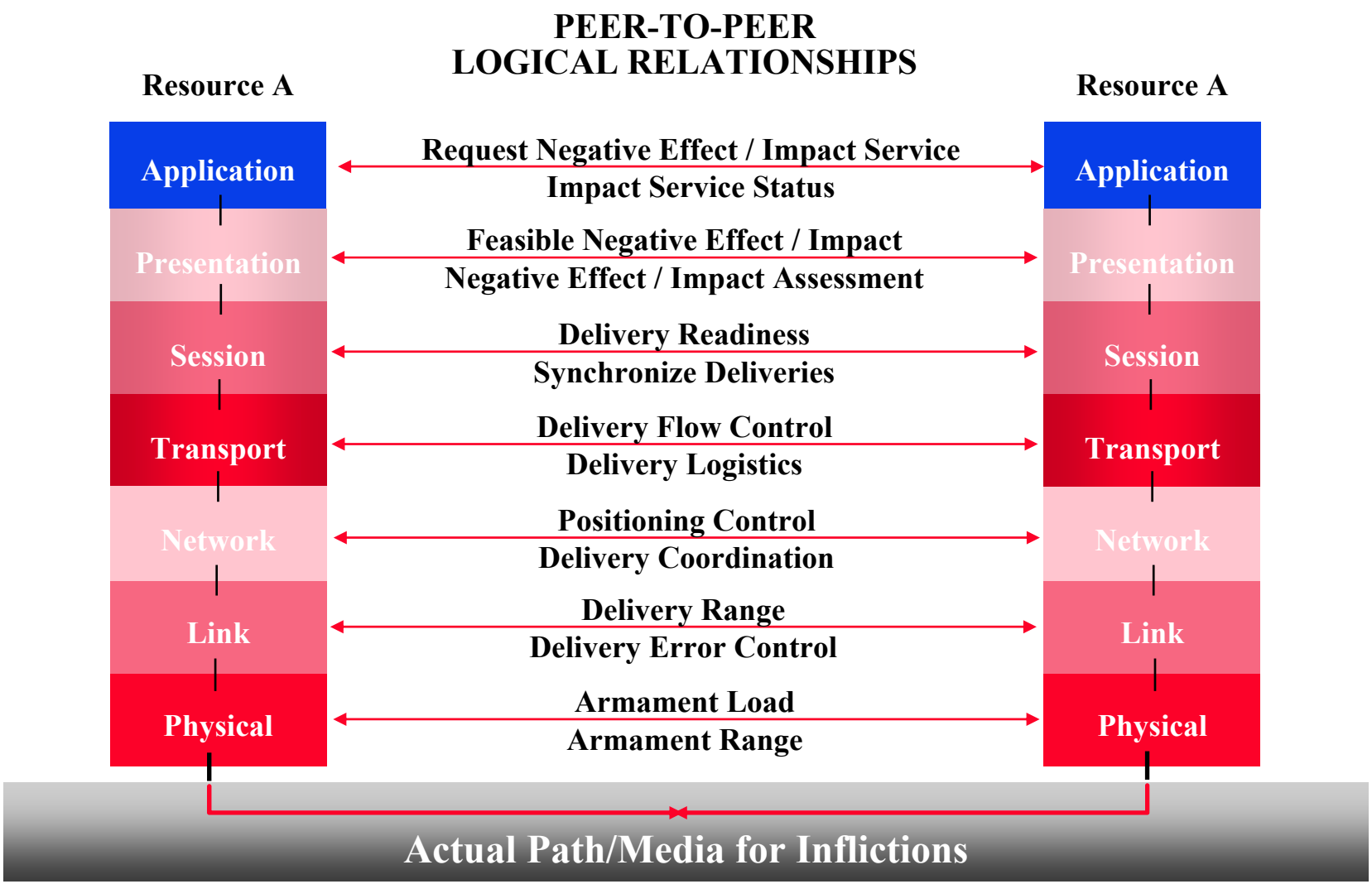
C2 applications Layers



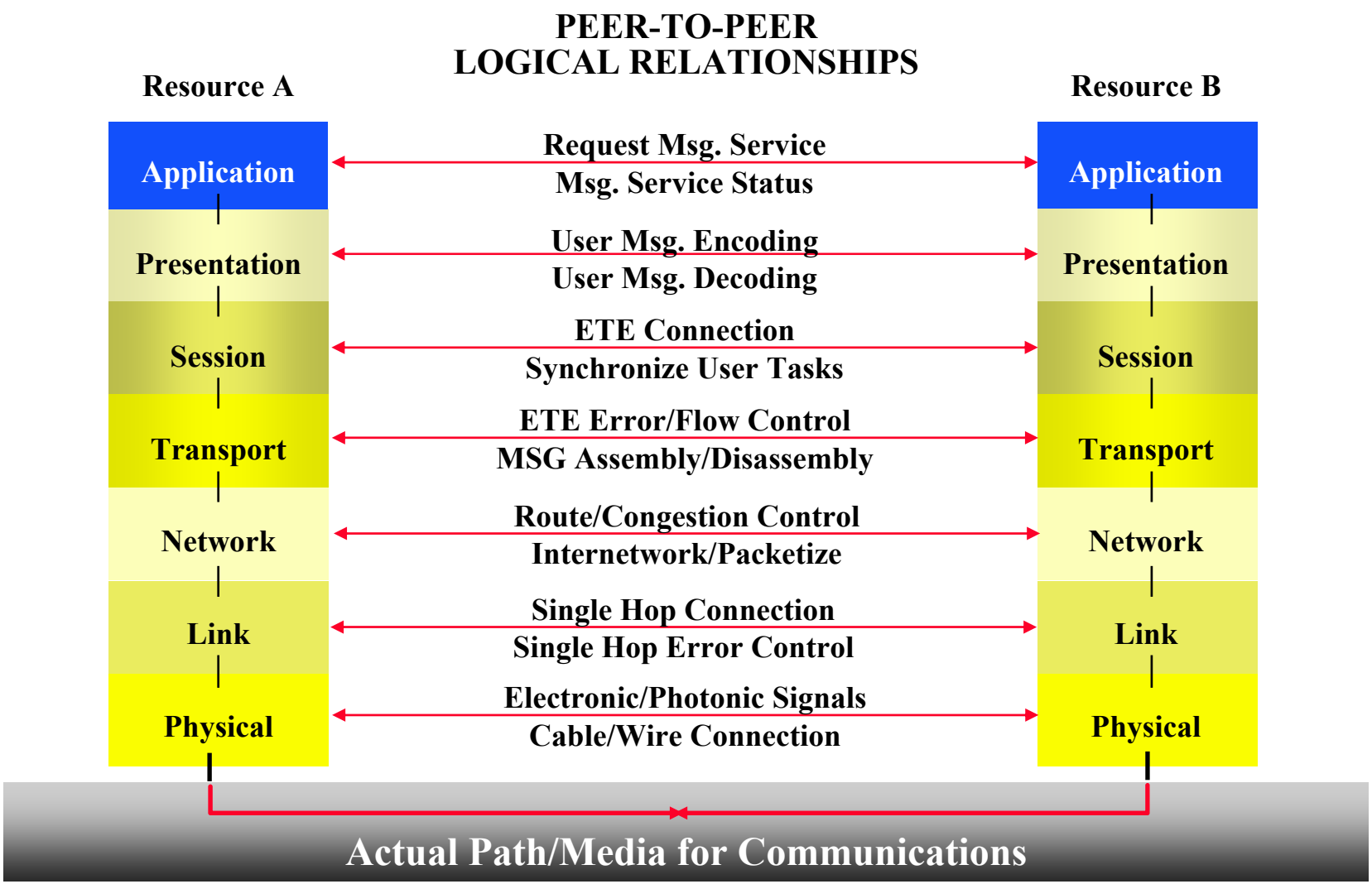
Identifications Layers



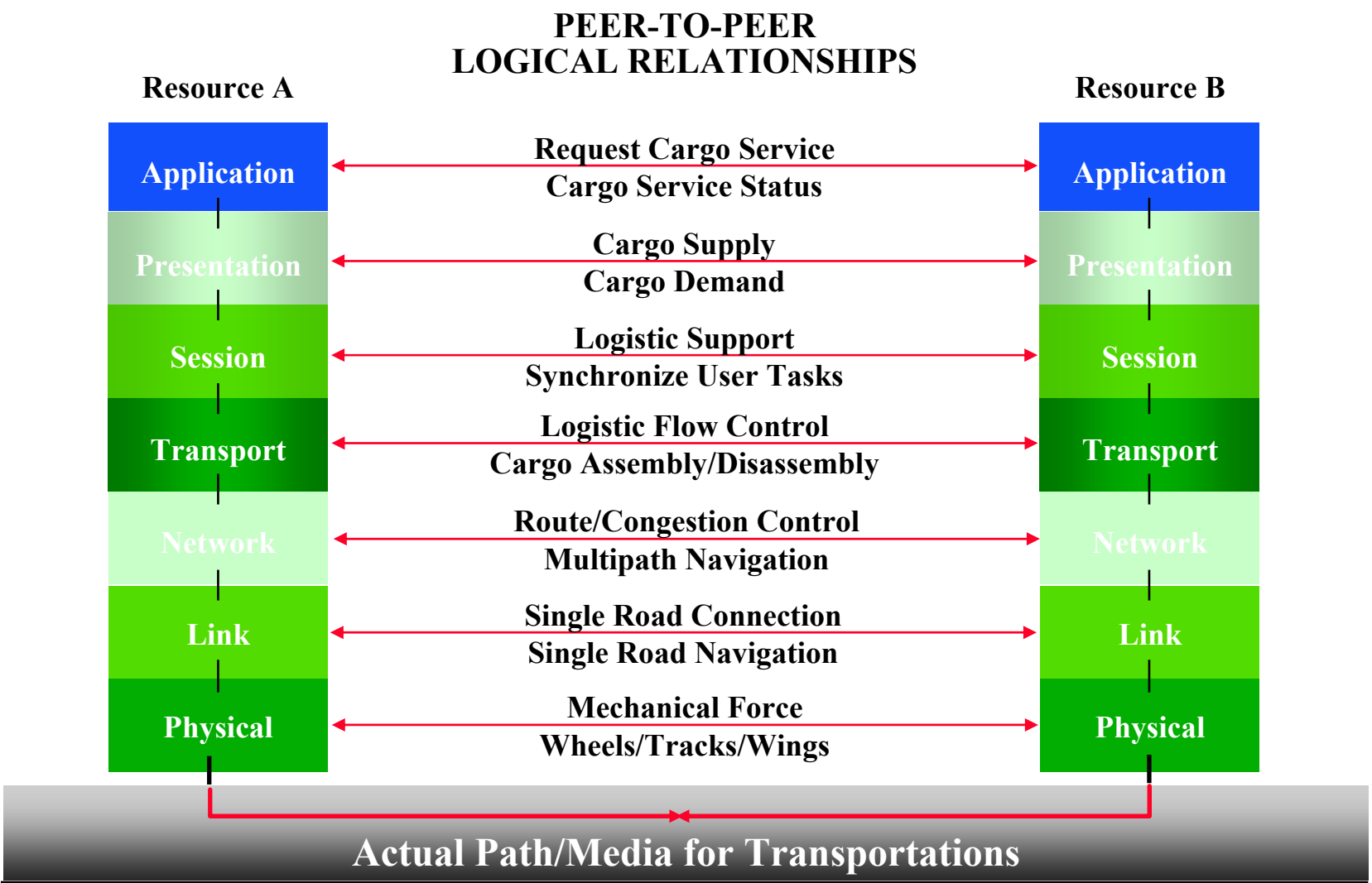
Inflictions Layers



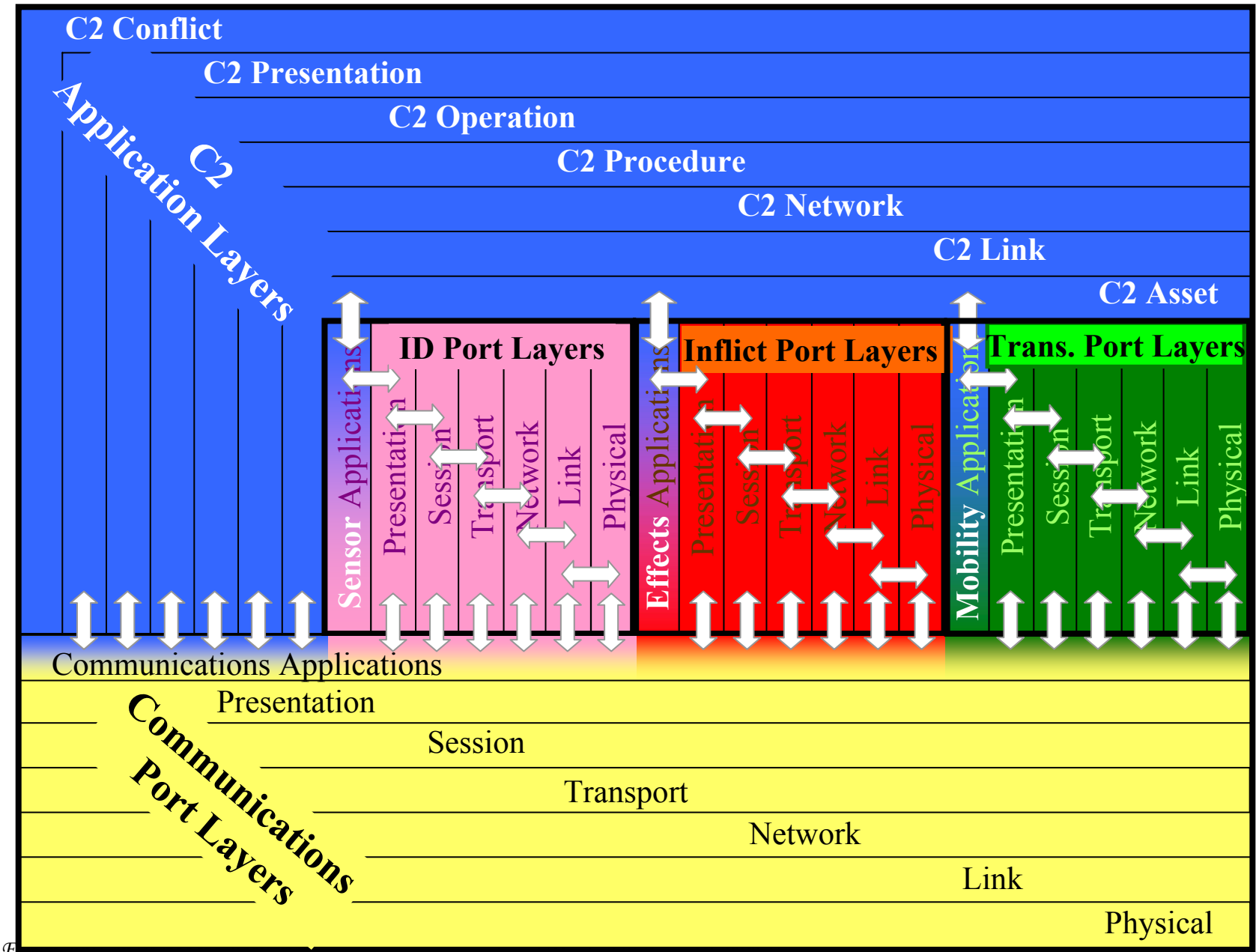
Communications Layers



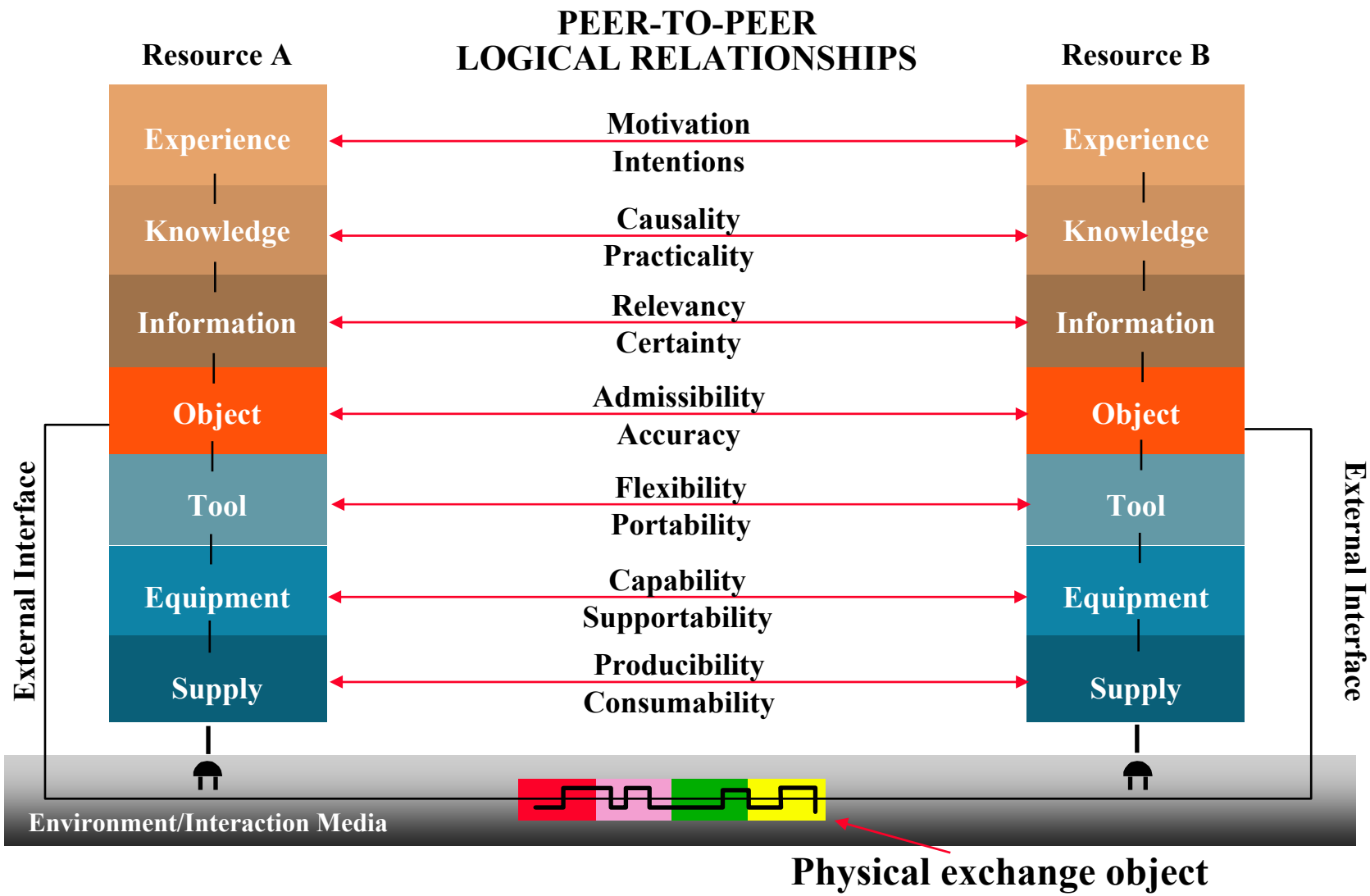
Transportations Layers



C2 and Port Layers Integration



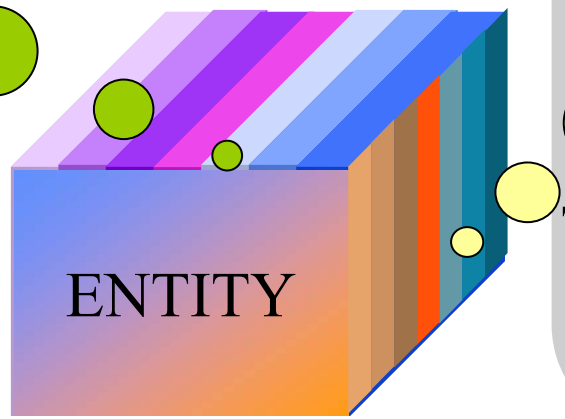
F33. Technology base layers



Entity Domains

- Missions
- Plans
- Tasks
- Jobs
- Assignments
- Transactions
- Packages

Problem-Solution Domain {Operational & Organizational}

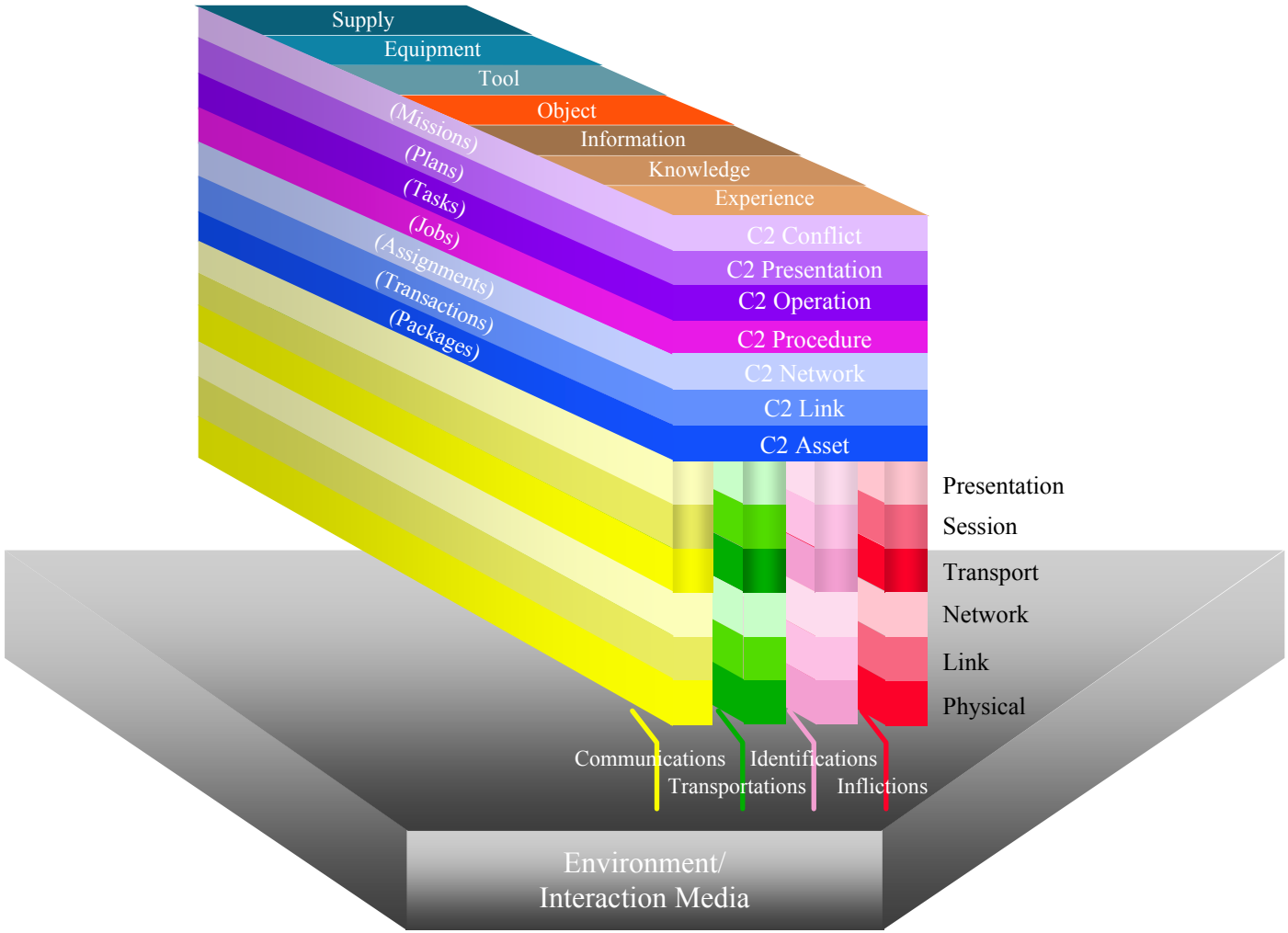


- Experience
- Knowledge
- Information
- Object
- Tool
- Equipment
- Supply

Technology-Implementation Domain {Technical & System}

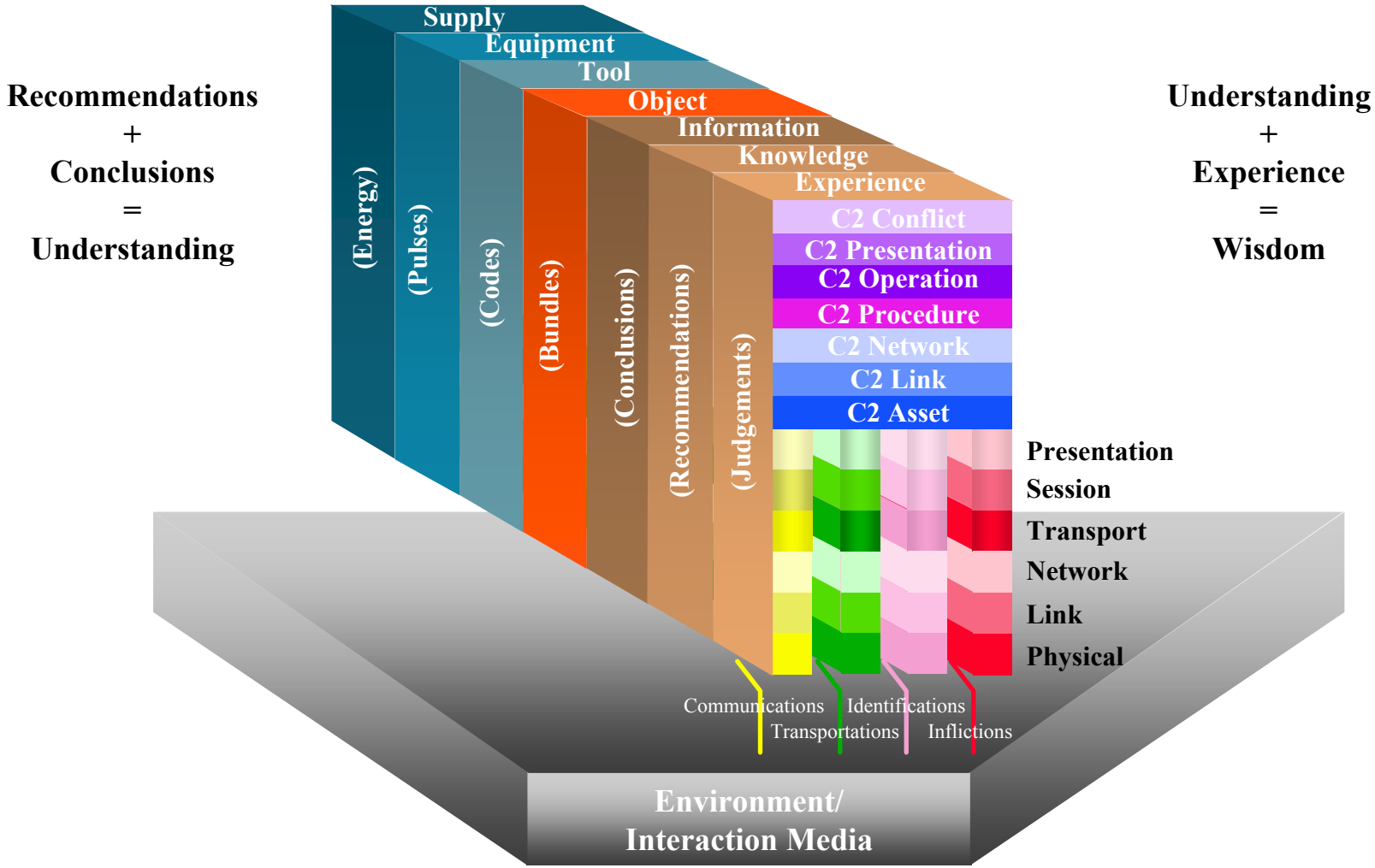
F32a. Inserting technology into C2 apps

- **A C2 perspective**



F32b. Inserting C2 into existing technology

- **A technology perspective**



TAnB1. C2RM Key Words

- **Coherent, Consistent Taxonomy**

Port:	Physical, Link, Network, Transport, Session, Presentation, Application
Interaction:	Communications, Transportations, Identifications, Inflictions
Official:	Operator, Coordinator, Administrator, Agent, Controller, Planner, Commander
Method:	Instruction, Technique, Discipline, Schema, Tactic, Strategy, Policy
Leader/Commander:	Expert, Partner, Captain, Manager, Director, General, President
Product/Requirement/Fact:	Package, Transaction, Assignment, Job, Task, Plan, Mission
Conflict:	Armament, Engagement, Combat, Battle, Campaign, War, Peace
Representation:	Energy, Pulse, Code, Bundle, Conclusion, Recommendation, Judgment
Base:	Supply, Equipment, Tool, Object, Information, Knowledge, Experience
C2 Application:	Asset, Link, Network, Procedure, Operation, Presentation, Conflict
Organization Module:	Item, Component, Entity, Element, Resource, Unit, Enterprise
C2 Service:	Environm't, Friend, Foe, Relative, Requirm't, Generat'n, Evaluat'n, Specificat'n
C2 Modes:	Assess, Develop, Monitor
Package:	Ordnance, Image, Message, Cargo
Problem/Solution (C2) Domain:	Command, Center, Staff, Applicat'n, Service , Utility, Facility
Implementat'n/Technology Domain:	Setting, Session, Phase, Base, Service, Utility, Facility
Services:	Display, Enter, Process, Store, Flow
Scenario:	Scenario, Snapshot, Overlay, Cell, Cr_object
Conflict Region (Cr) Object:	Unit, Coordination, Environment

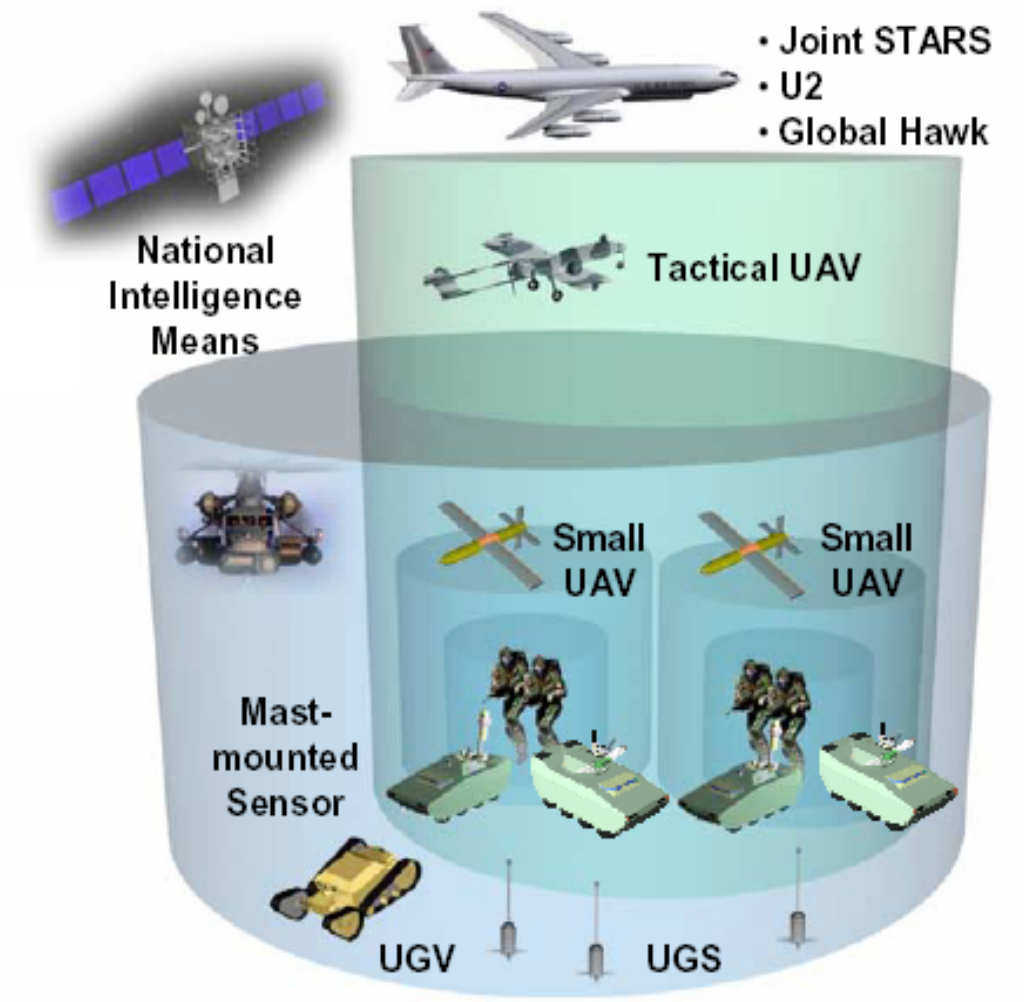
Statement elements: Who(source), What(action), Whom/Which(target), When, Where, How, Why(outcome)

Network-Centric Battlespace

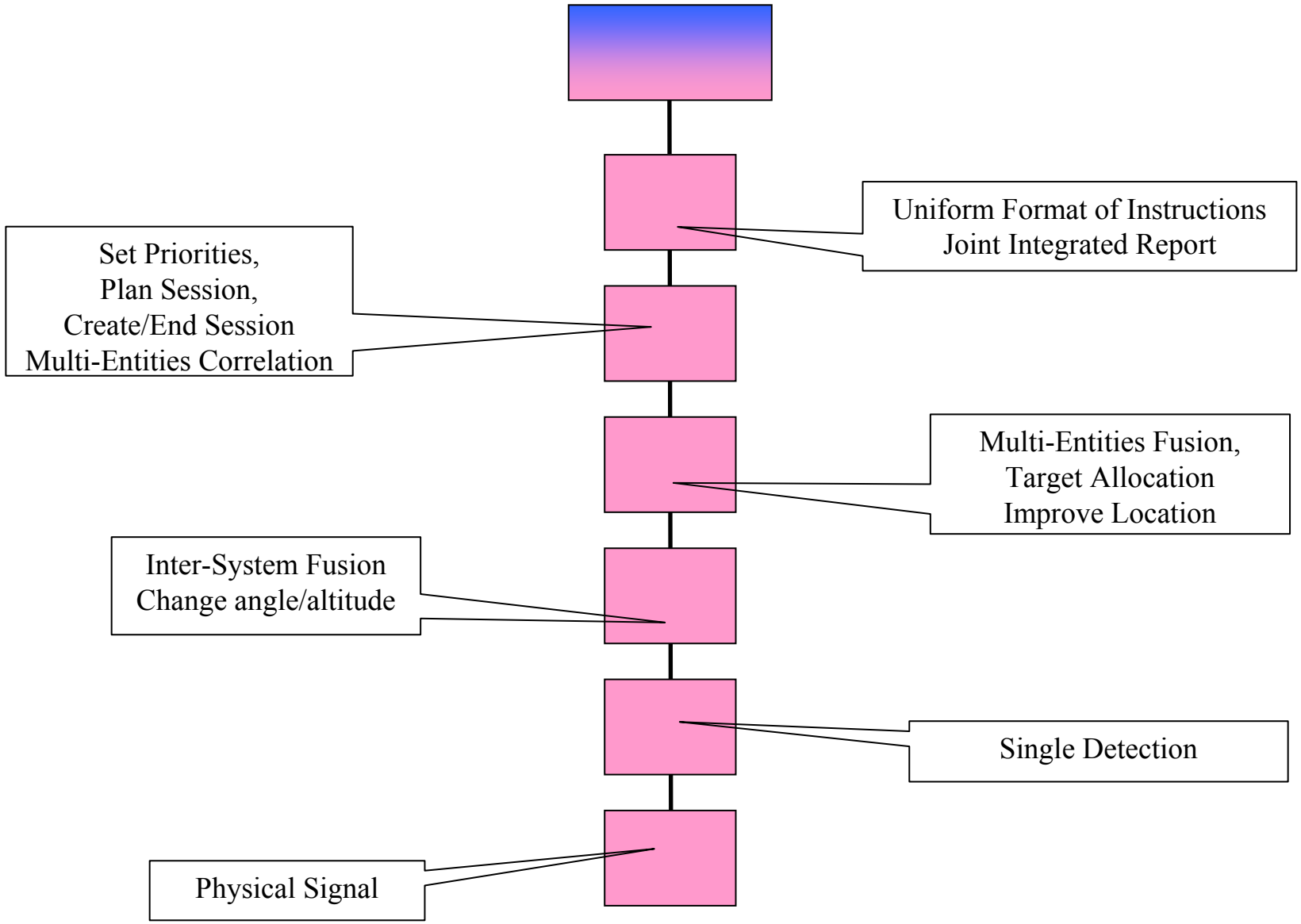
The **Massive amount** of Reconnaissance and Surveillance assets forces distributed control, distributed processing and semi-autonomous collaboration between the assets.

The goals are:

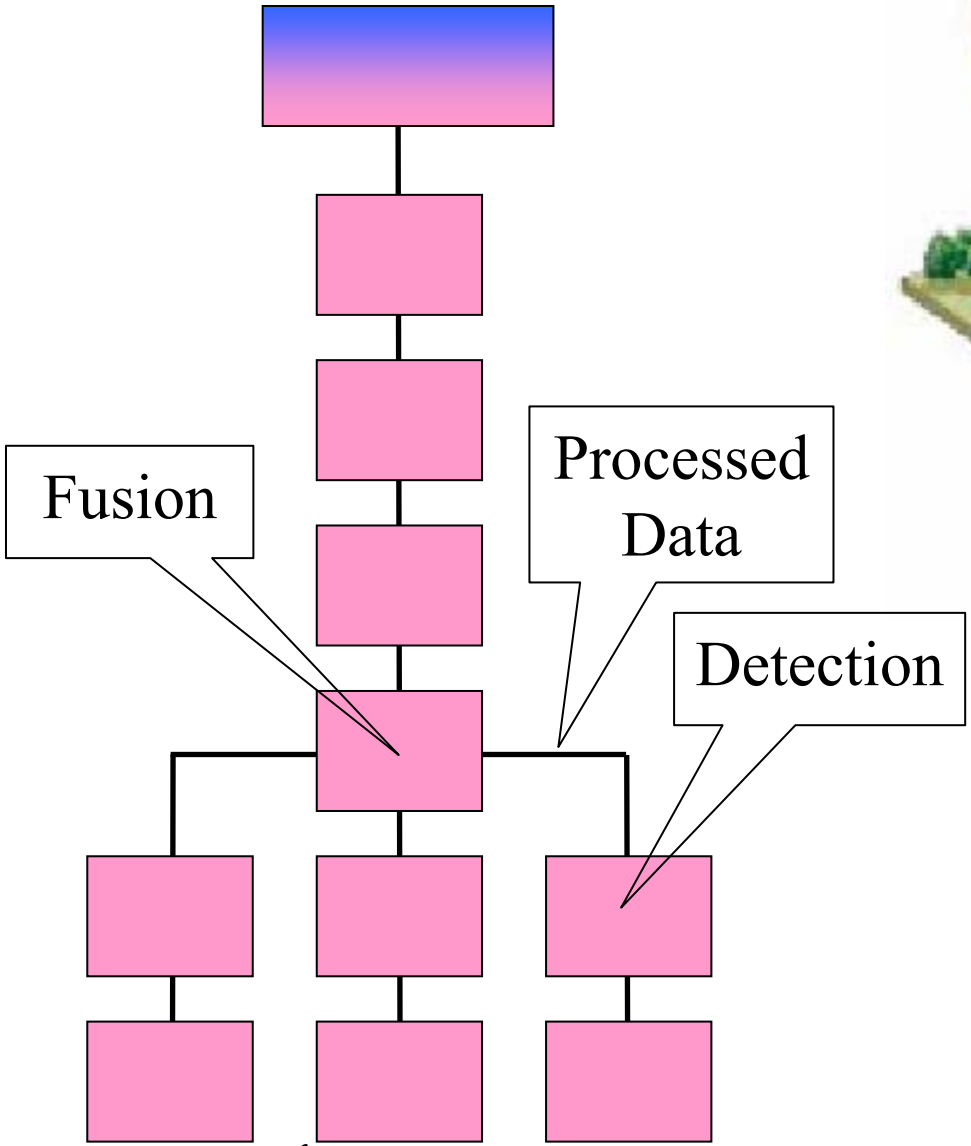
1. Only Identified and Verified objects emerge.
2. Efficient deployment of the Sensors.
3. Reduced number of errors and false alarms.
4. Saving bandwidth.

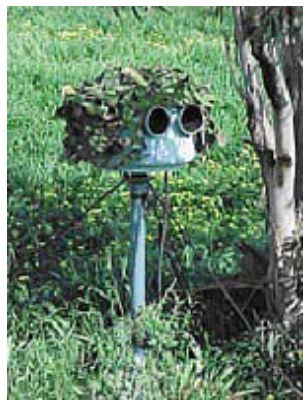


Identification Asset

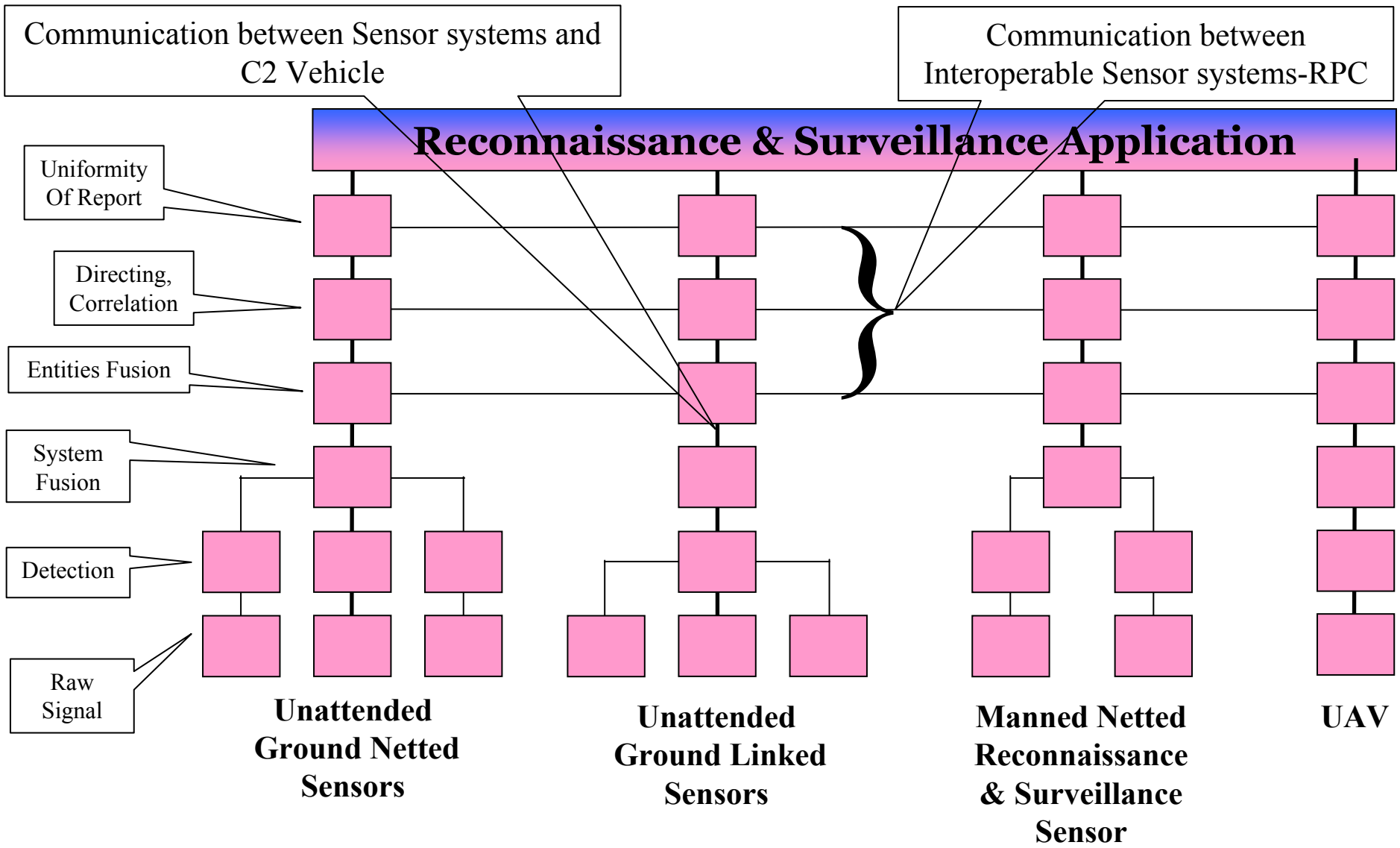


Unattended Ground Netted Sensors

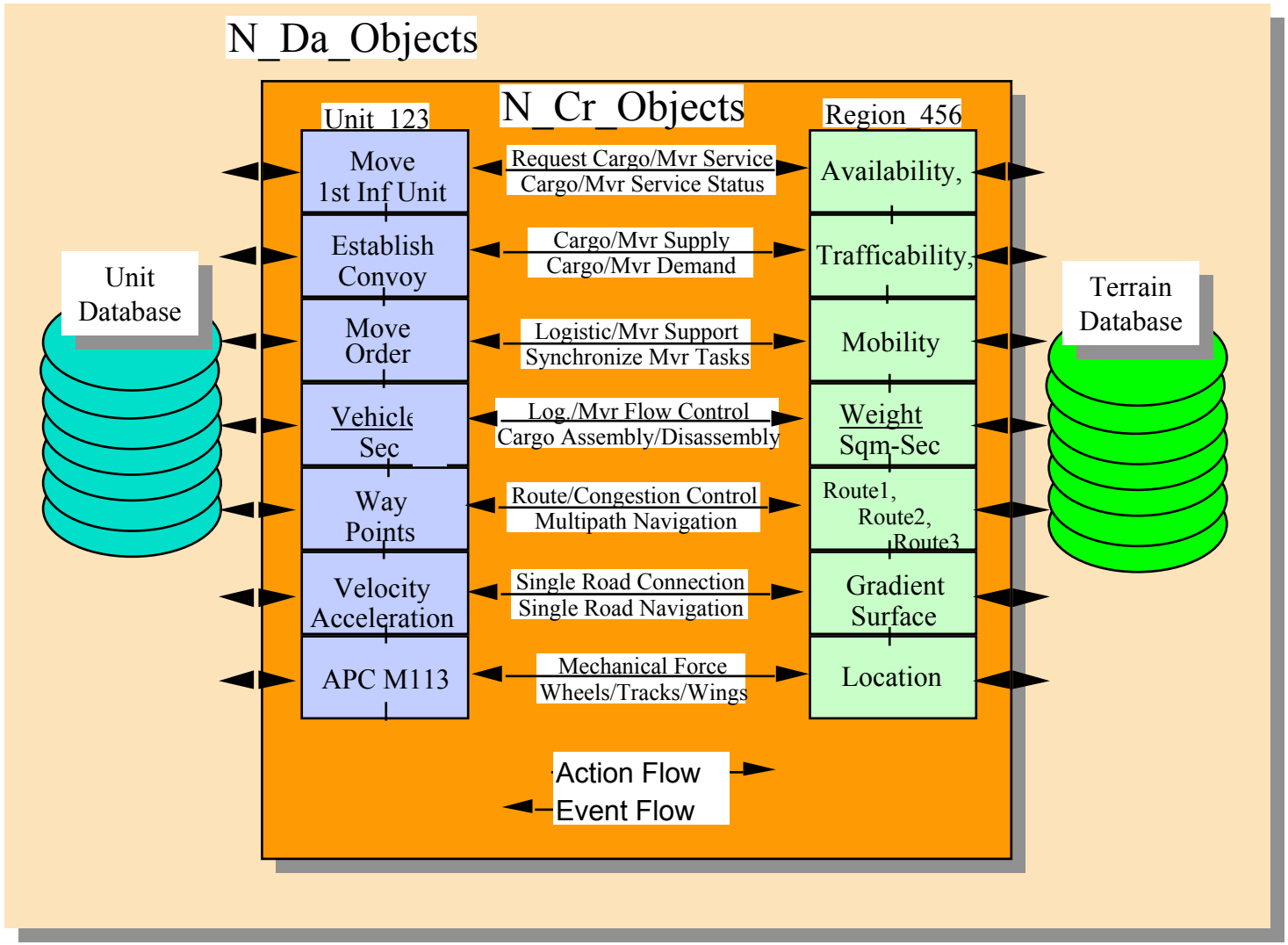




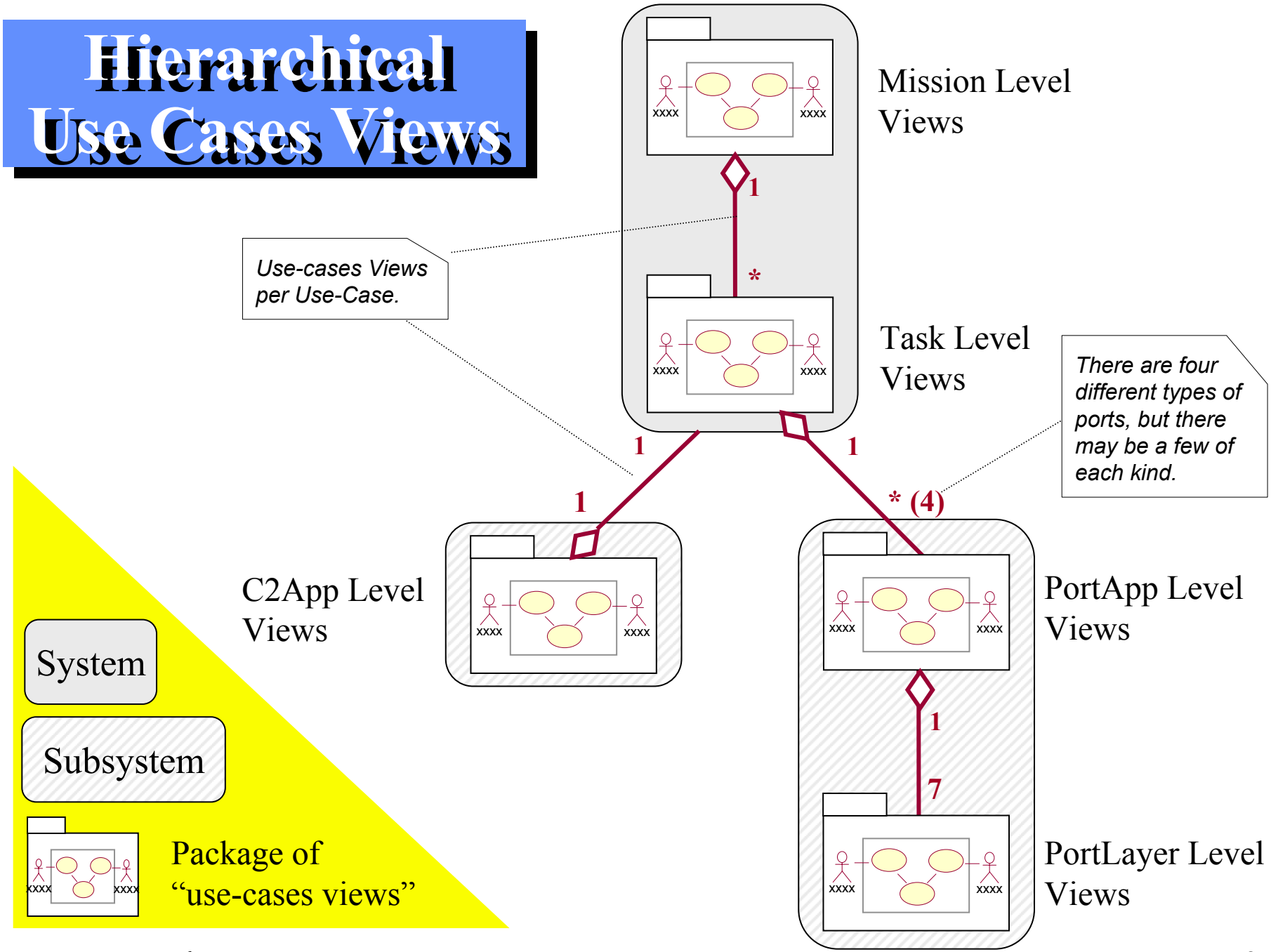
Layered Multi-Sensor Integration



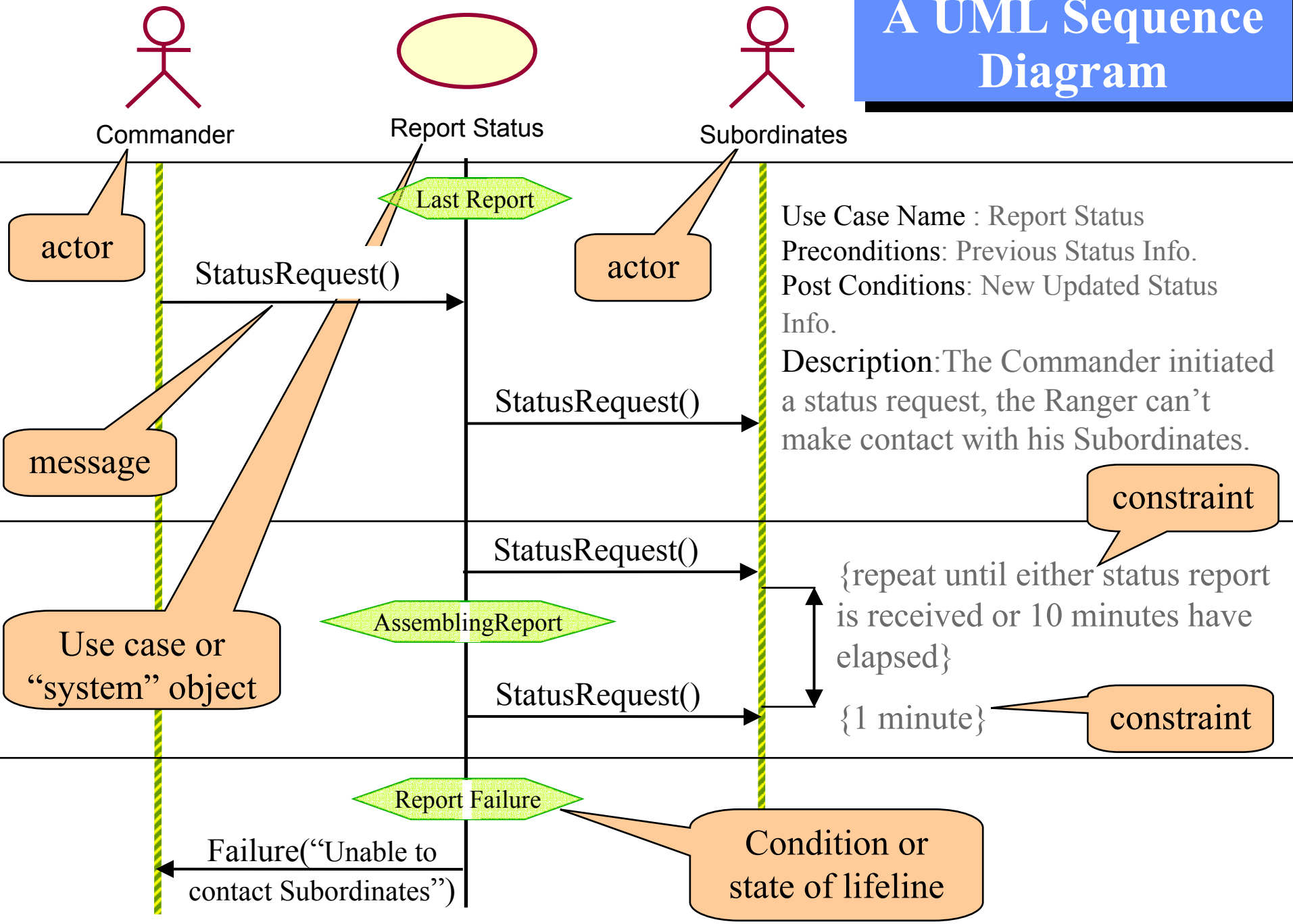
Cr_object Layered_interaction



Hierarchical Use Cases Views

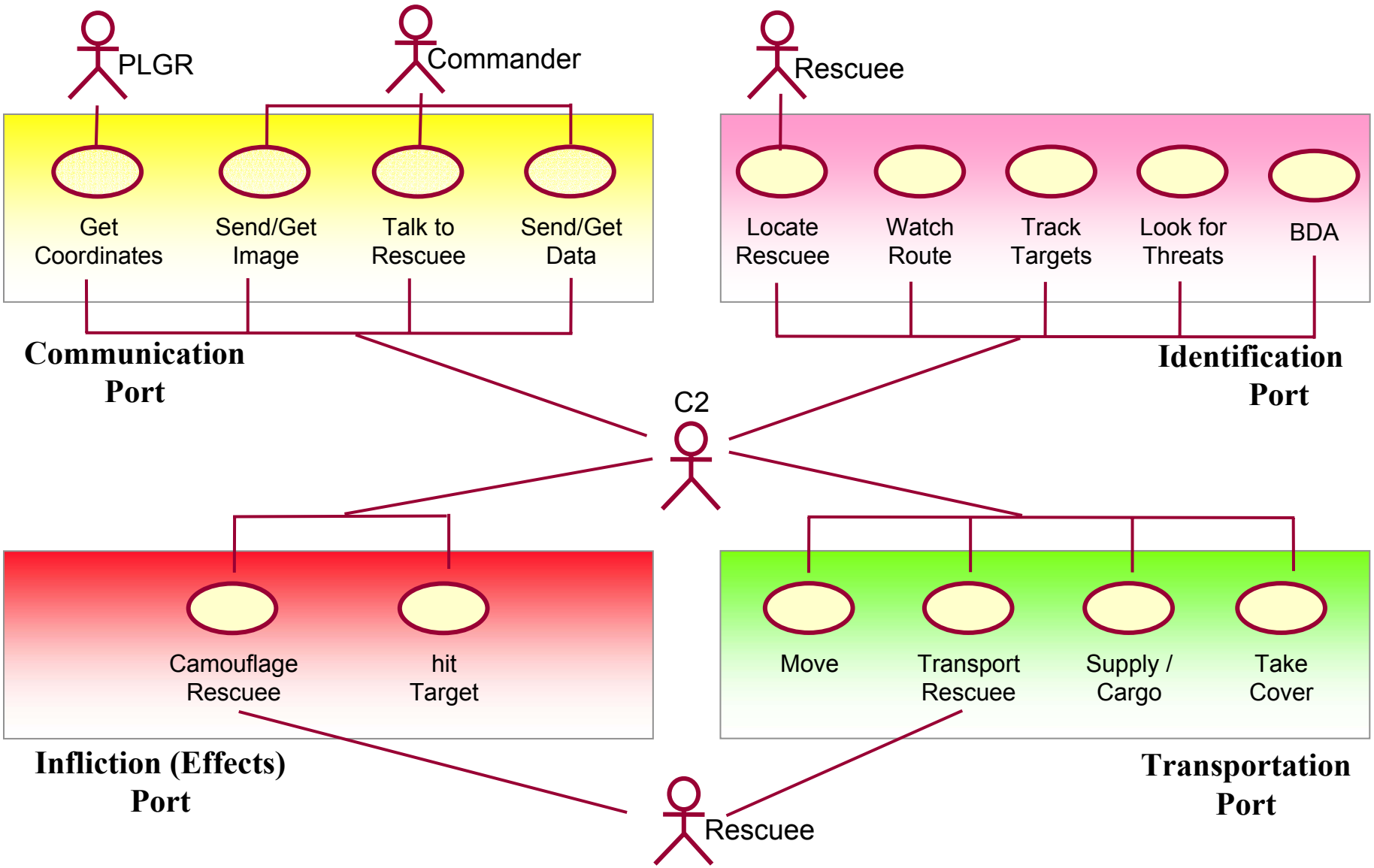


A UML Sequence Diagram

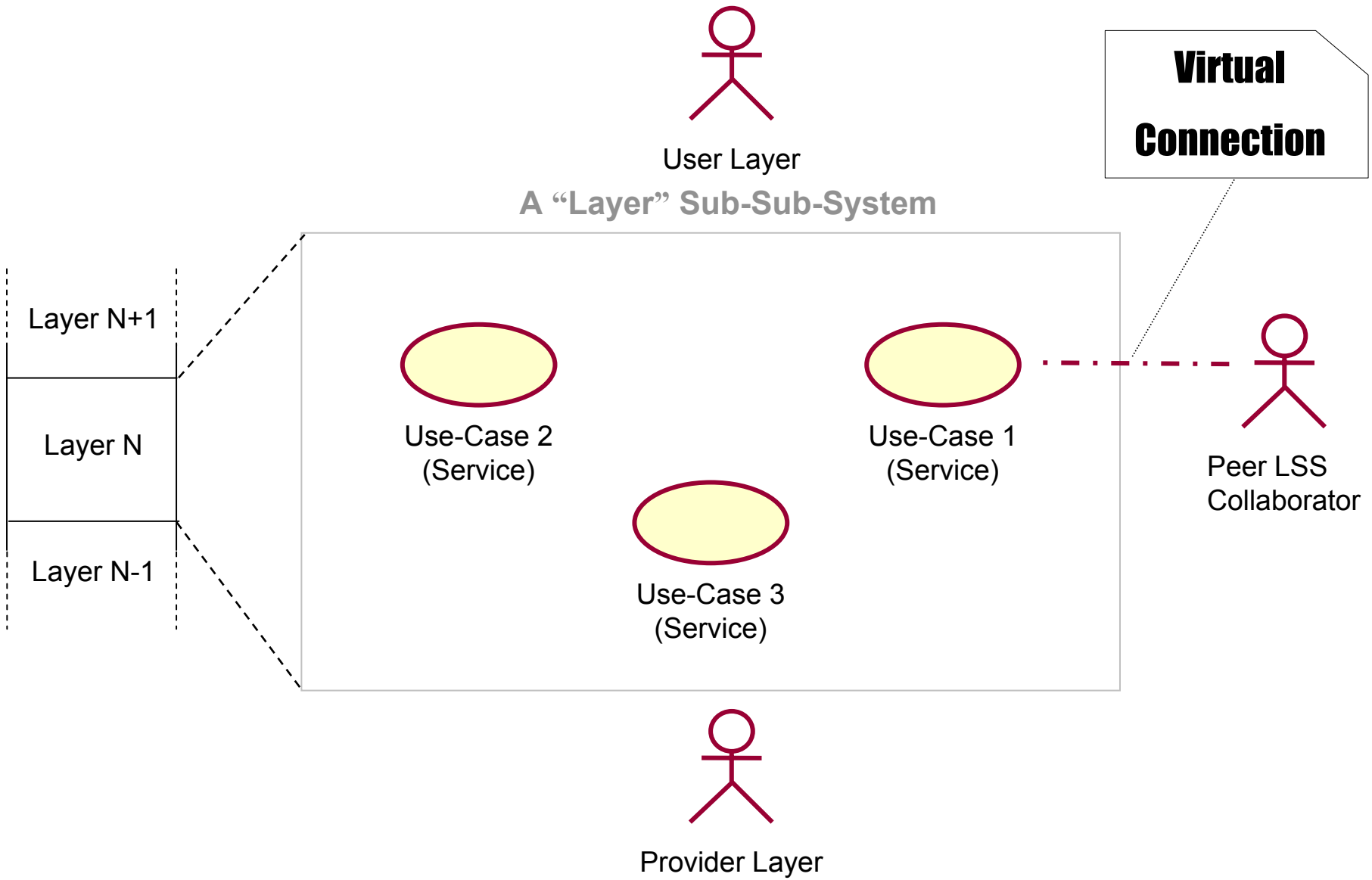


Warfighter Ports Use Cases

(Example)

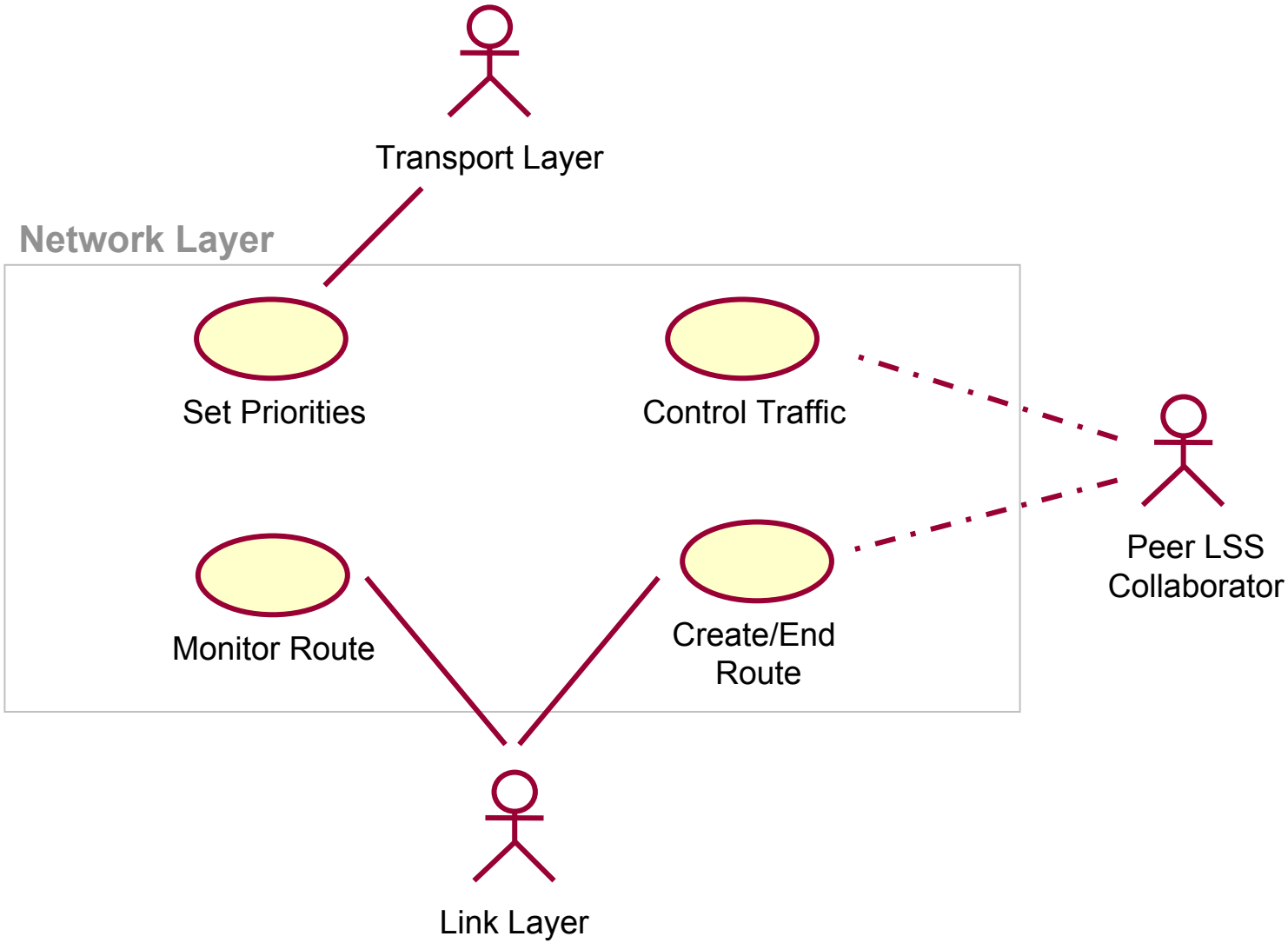


Zoom-in on a Typical Layer



LSS – Layer Subsystem

Communication Network Layer

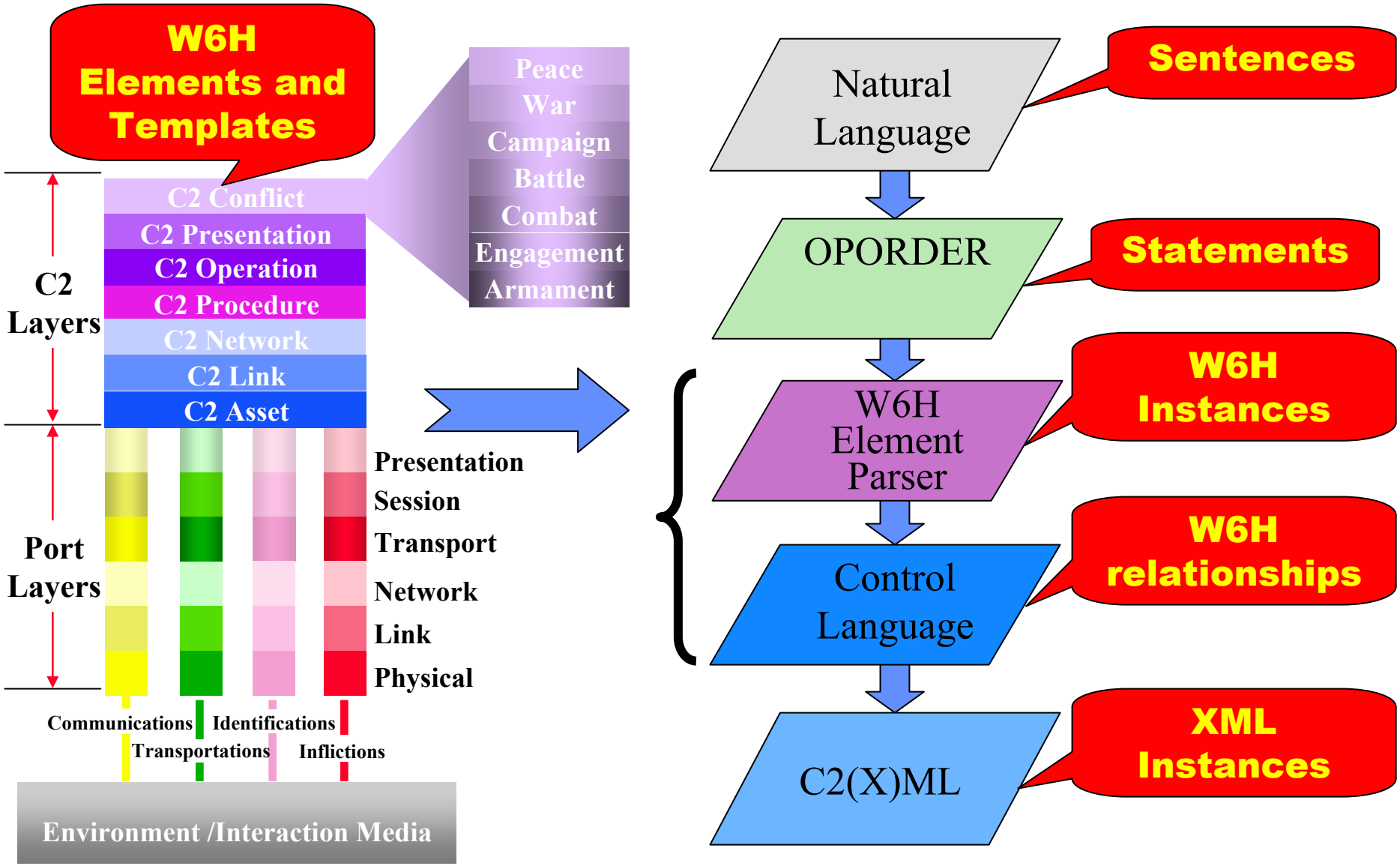


LSS – Layer Subsystem

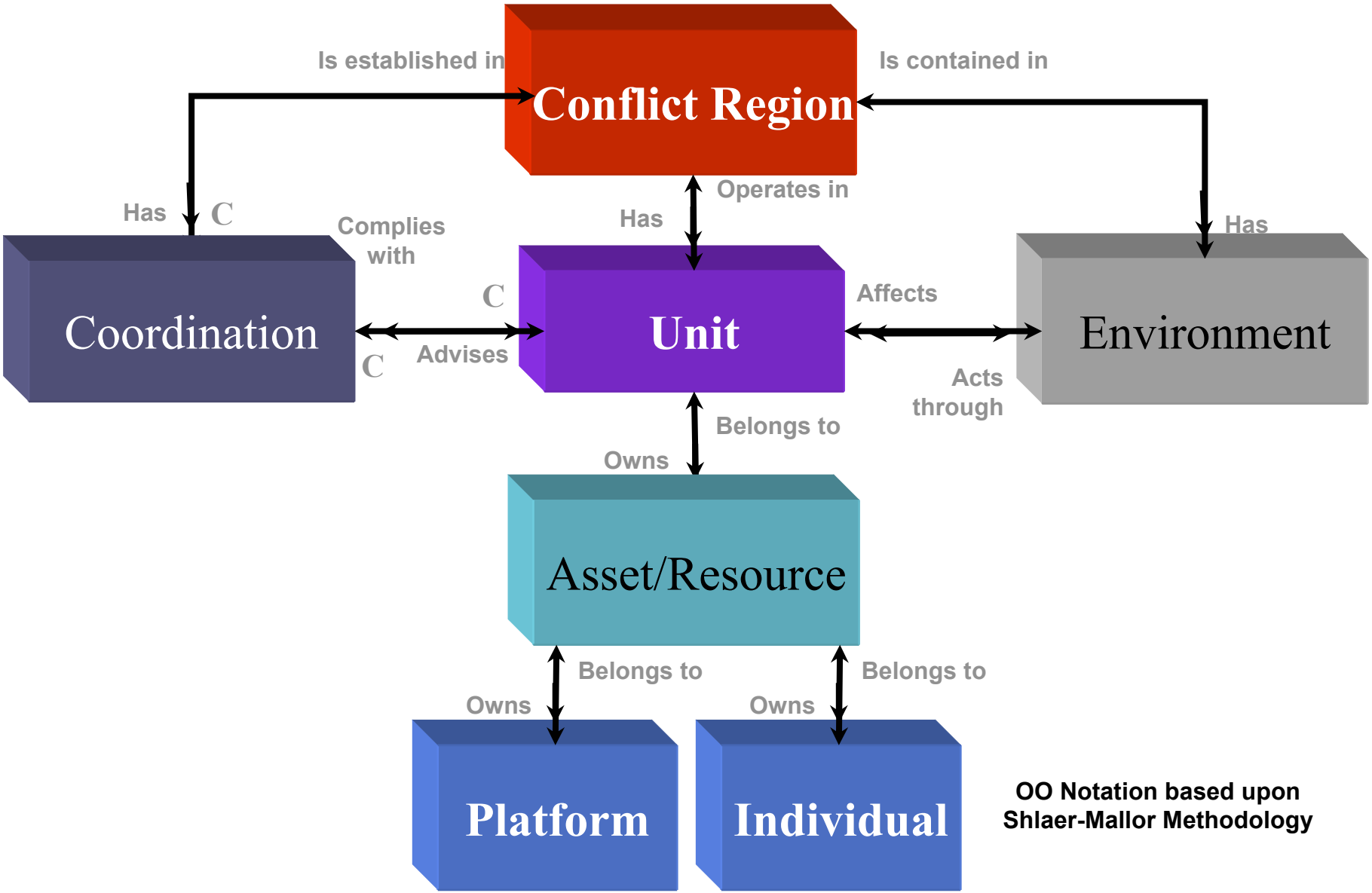
Layered Port Classes and Subclasses

GENERAL PORT	Identification	Communication	Infliction	Transportation
Joint Integrated Report		Encryption		
	ISR Data	Compression	Effect Data	Supply Data
Synchronize user tasks	ICD/IFF	Enable logon, Establish QoS	Authorize Weapon Establish Possible Effect	Cargo Supply/Demand
Set Priorities / Plan Session	BD.A			Monitor Unit's Location
Flow Control	Multi-Entities Fusion	Assemble/Disassemble Packets	Match Munitions to Desired Effects	Assemble/Disassemble Cargo
Resource Allocation	Classify/Verify			
Position Control	Multi-Sensor Correlation	Route Connection	Assign Fire Nodes	Route Connection
		Traffic Control		
Track Connectivity	Single Detection	Single Hop Connection	Aim / Guide	Single Road Navigation
			Control Fire Tempo	
Operate	Power Sensor	Power Radio	Arm Weapon	Fuel Vehicle

Formalizing C2 Products

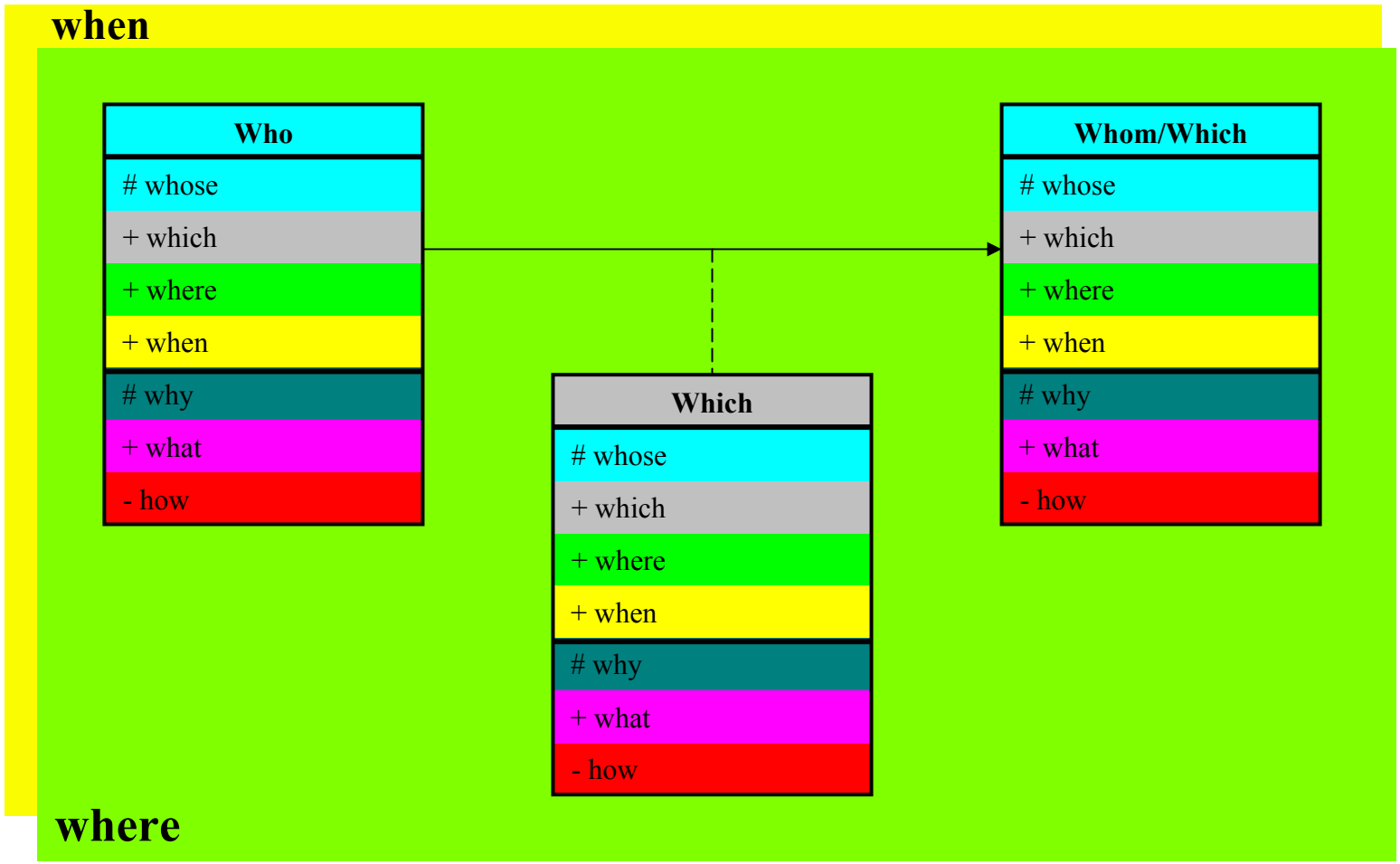


OO Conflict Region Information Model

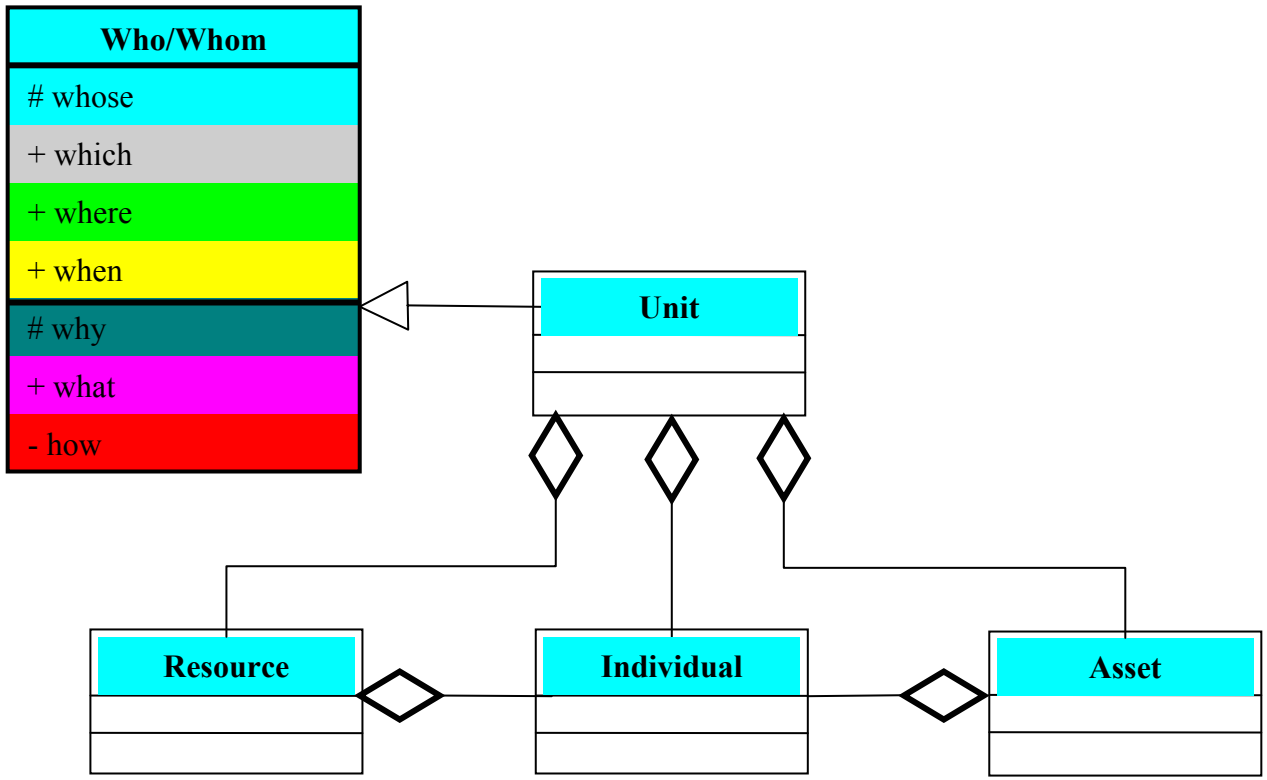


OO Notation based upon Shlaer-Mallor Methodology

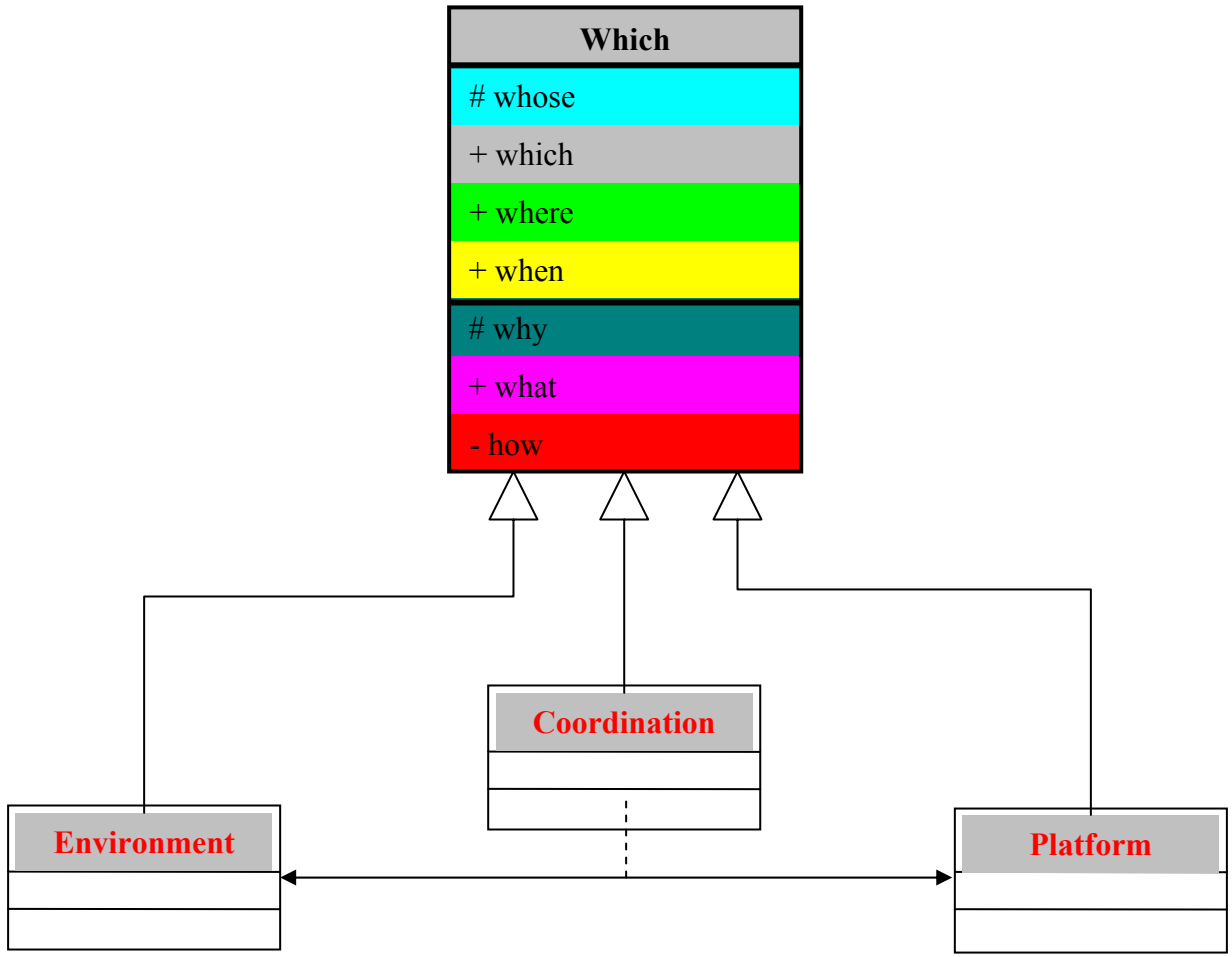
W6H Class Diagram



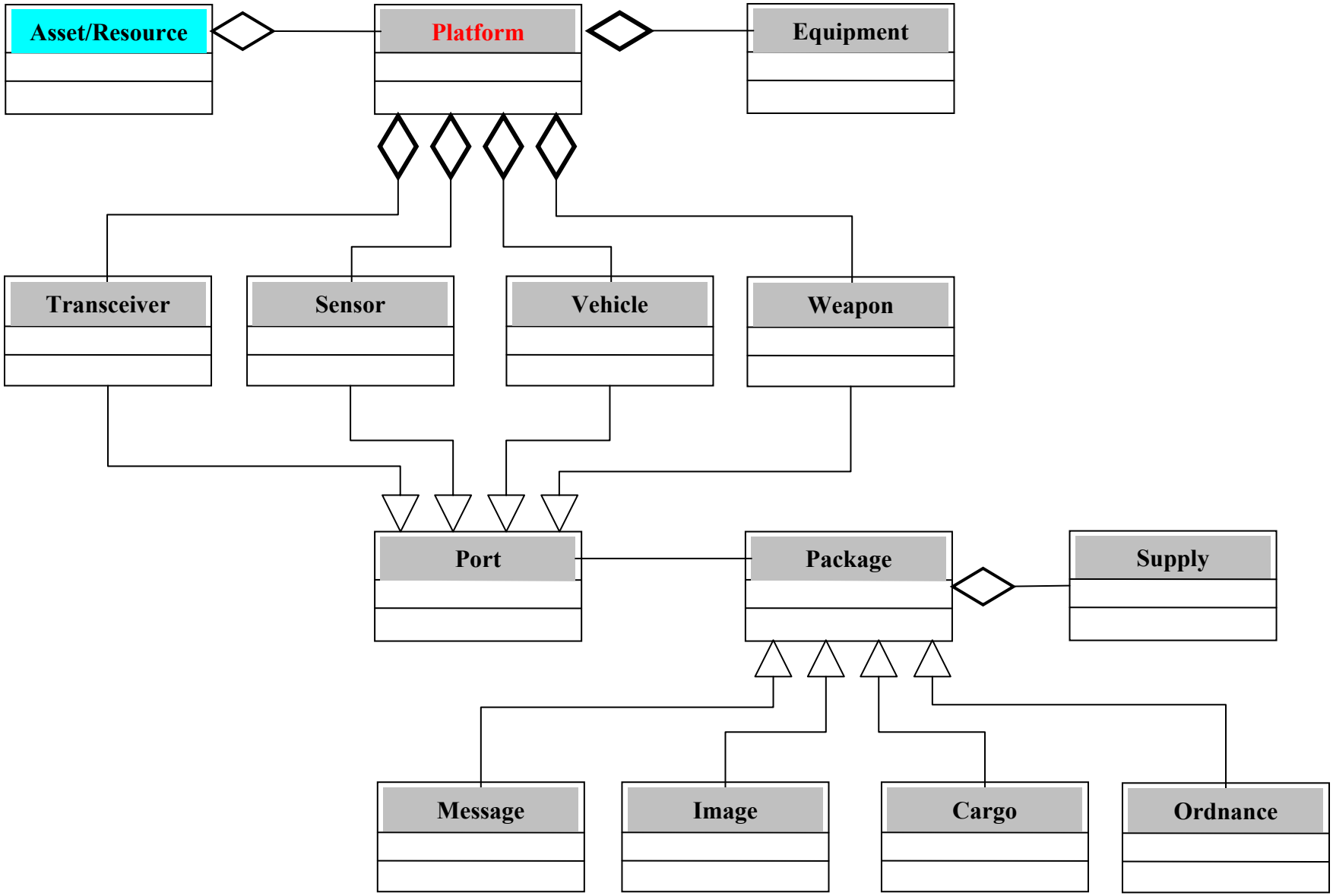
The “Who” / “Whom” Class



The "Which" Class

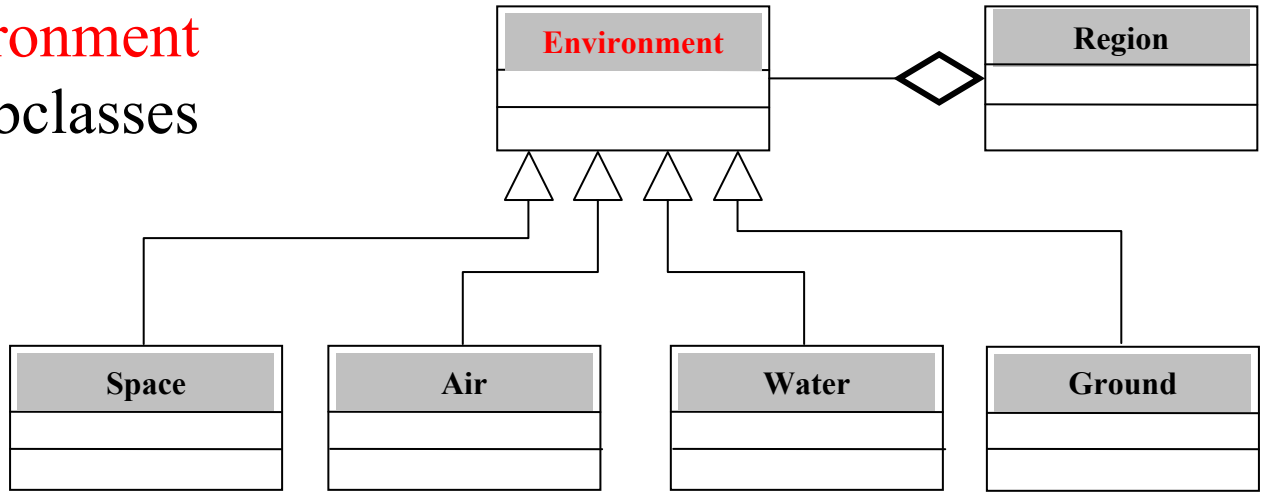


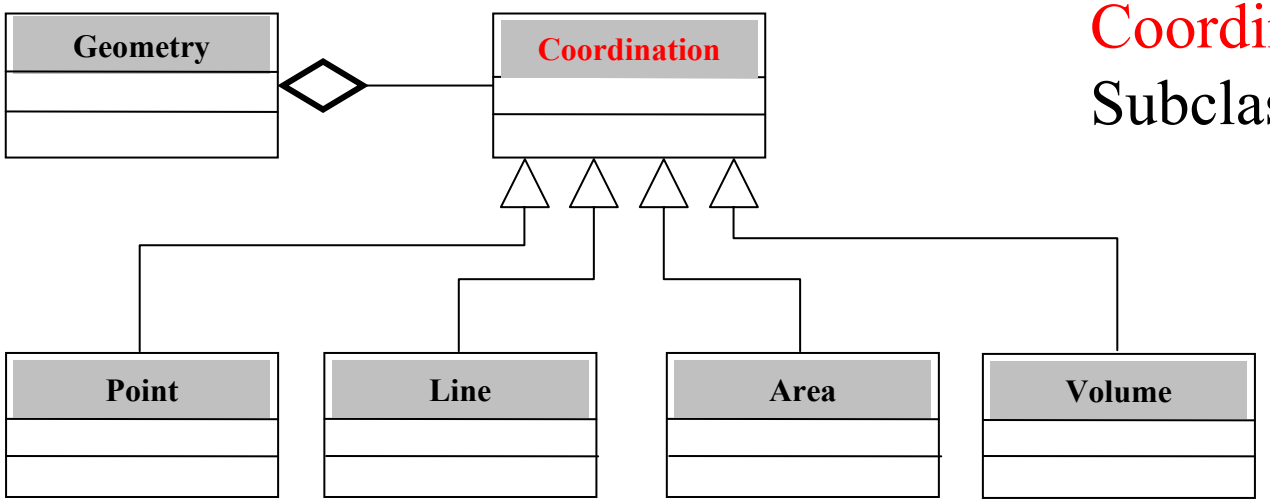
The "Which" Platform Subclasses



The Other "Which" Subclasses

Environment
Subclasses





Coordination
Subclasses

Control Language for C2 Products

Control Language Definition

Control Language is made of simple sentences(associations) using 2 or more W6H Elements constructs. There are two types of constructs: Main and Supplemental

* **Main Constructs** includes all W6H elements **at most one time**.

  Who (does) **what** (action) (to) **whom** (with) **which**, **where**, **when**, **why** and **how**.

* **Supplemental Constructs** are derived using UML-based Domain Object statements:

  Which W6H element is **include**d in which other W6H element?
  Which W6H element is **extend**ed by which other W6H element?
  Which W6H element is a **generalization/specialization** of which other W6H element?
  Which W6H element is an **aggregate (shared/composite)**of which other W6H element?
  Which W6H element is **equivalent** to which other W6H element?

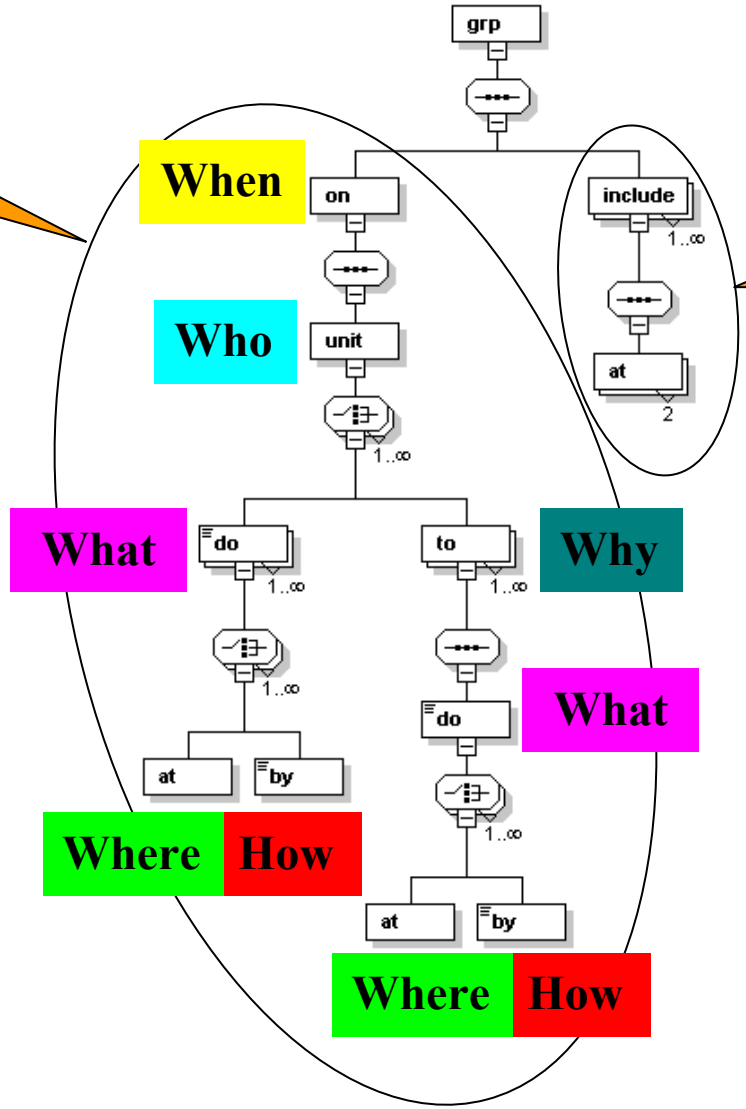
Commander's Intent Example W6H Relationships

Who(1st Armored Brigade) **What**(destroy) **Whom** (enemy) **Which** (using minimum force)
Where (in objective area) **When (**on order)
Why (to ensure safe forward passage by 21st Infantry Division)
How (immediate, wedge formation,)

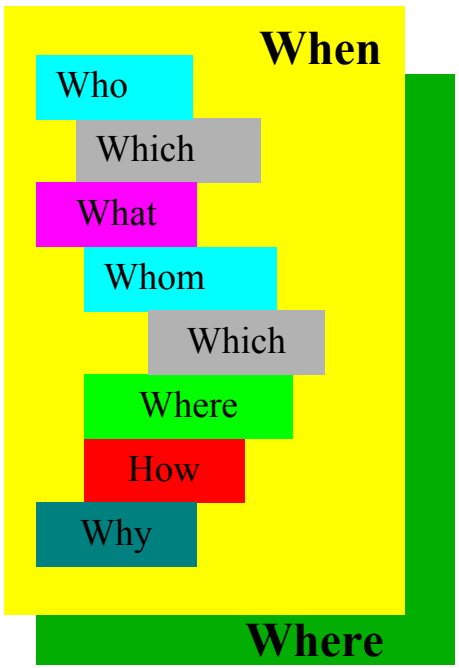
An XML Schema Using W6H Constructs

Main Construct

Supplemental Constructs



Color Schema



When→on
Who→unit
Which→asset
What→do
Whom→unit
Where→at
How→by
Why→to

Singly-Nested Main Statement Elements Constructs Schemata

When (for a given statement)
- Where (for the given When)
- Who (is at the given When)
- What (occurs at the given When)
- Whom (is at the given When)
- How (the When is bounded and subdivided)
- Why (use the given When)

What (occurs for the given When)
- When (for the given What)
- Where (is the What)
- How (is the What affected by the Where)
- Why (use this particular What)

Who (for at the given When)
- When (for the given Who)
- Where (is the Who)
- How (does the Who implements the What)
- Why (use this particular Who)

Whom (for the given When)
- When (for the given Whom)
- Where (is the Whom)
- How (is the Whom affected by the What)
- Why (use this particular Whom)

Where (for the given When/Who/What/Whom)
- How (is the Where bounded and subdivided)
- Why (use this particular Where)

How (for the given When/Where/Who/What/Whom)
- Which (parts are used for this particular How)
- Why (use this particular How)

Why (use this particular When/Where/Who/What/Whom/How)
- Which (reason is applicable for this Why)

Identifying W6H Elements in OPORDER

OPORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone

W6H Elements	W6H Metadata
Who /whom/whose:	unit, resource, asset, individual
What (do):	action, plan, operation, task, mission, results, status, outcome
Which (object/product):	platform, equipment, supply, system, package(messages, images, cargo, ordnance)
Where (at):	place, vicinity, coordinates, region, location, position
When (on):	datetime, event, before, after, during, parallel, sequential, o/o
Why (to):	purpose, goal, objective
How (by):	organization, formation (arrangements of forces for specific purposes), command relationship (degree of control responsibility), timing

W6H Elements for OPORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone

Transforming Natural Language to Control Language

W6H Elements for OPORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone

W6H General rules:

Each sentence is composed of a set of W6H elements. Each complex W6H element may be decomposed into W6H sub-elements. Iterate W6H rules for each complex W6H element. Apply template/logic to relate between W6H elements and sub-elements. Apply template/logic to relate between abstract references and concrete context.

W6H Element rules:

Find conjunctions and separate complex sentences into simple sentences. Find pronouns and substitute names from context. Identify non-essential background information. Find noun phrases to identify **who** and **whom**.
Find verb phrases to identify **what** actions are taken. Look for the temporal phraseology (time) to extract **when**.
Look for spatial phraseology (places) to extract **where**. Identify **how** for each **what** if any. Find goal phrases by looking for "to" "for" "because" and other "rationale" phraseology to identify **why**.

W6H Association Rules:

Associate lower-level W6H sub-elements with higher corresponding W6H element. Identify the following relationship:
Who to Whom, Whom to Who, Who to Which, Whom to Which, Who to What, What to Whom, Who to When, What to When, Who to Where, Where to Where, When to When, Who to Why, What to Why, What to How, etc.

W6H Relationships for OPORDER Excerpt (Control Language)

IBCT is a US unit
On order **IBCT** deploys to MACRAN REPUBLIC
On order **IBCT** moves immediately to zone
IBCT **secures** zone. **IBCT** **establishes presence** throughout zone
Zone is in Kazar. **IBCT** is in zone
Kacanic Corridor is in zone. Pristina Airfield is in zone. Pristina is in zone

Tagging W6H Control Language Constructs

Control Language Constructs	XML tagging applied to Control Language Constructs
IBCT is a US unit	<unit type="tactical" name="IBCT" id="1st" role="Combat" size="Bde Team" aff="US" cmps="(+)"/>
On order IBCT deploys to MACRAN REPUBLIC	<on type="order"/> <do type="task">deploy</do> <at type="state" name="MACRAN REPUBLIC" associate_do="arrive"/>
On order IBCT moves immediately to zone	<do type="task">move</do> <by type="rate">immediately</by> <at type="zone" name="" associate_do="arrive"/>
IBCT secures zone	<to><do type="task">secure</do> <at type="zone" name=""/> </to>
IBCT establishes presence throughout zone	<to><do type="task">establish presence</do> <at type="zone" name=""/></to>
zone is in Kazar	<include><at type="zone" name=""/><at type="region" name="Kazar"/></include>
KACANIC CORRIDOR is in zone	<include><at type="corridor" name="KACANIC"/><at type="zone" name=""/> </include>
PRISTINA Airfield is in zone	<include><at type="airfield" name="PRISTINA"/><at type="zone" name=""/></include>
PRISTINA is in zone	<include><at type="city" name="PRISTINA"/><at type="zone" name=""/></include>

Resulting XML Instance of OPORDER Excerpt

(Expanded Form)

```
<?xml version="1.0" encoding="UTF-8"?>
<grp type="Situation/Friendly Forces" fnc="Mission">
    <on type="order">
        <unit type="tactical" name="IBCT" id="1st" role="Combat" size="Bde
Team" aff="US" cmps="(+)">
            <do type="task">deploy<at type="state" name="MACRAN REPUBLIC"
associate_do="arrive"/>
            </do>
            <do type="task">deploy<by type="rate">immediately</by>
                <at type="zone" name="" associate_do="arrive"/>
            </do>
            <to>
                <do type="task">secure<at type="zone" name=""/>
                </do>
            </to>
            <to>
                <do type="task">establish presence<at type="zone" name=""/>
                </do>
            </to>
        </unit>
    </on>
    <include>
        <at type="zone" name=""/>
        <at type="region" name="Kazar"/>
    </include>
    <include>
        <at type="corridor" name="KACANIC"/>
        <at type="zone" name=""/>
    </include>
    <include>
        <at type="airfield" name="PRISTINA"/>
        <at type="zone" name=""/>
    </include>
    <include>
        <at type="city" name="PRISTINA"/>
        <at type="zone" name=""/>
    </include>
</grp>
```

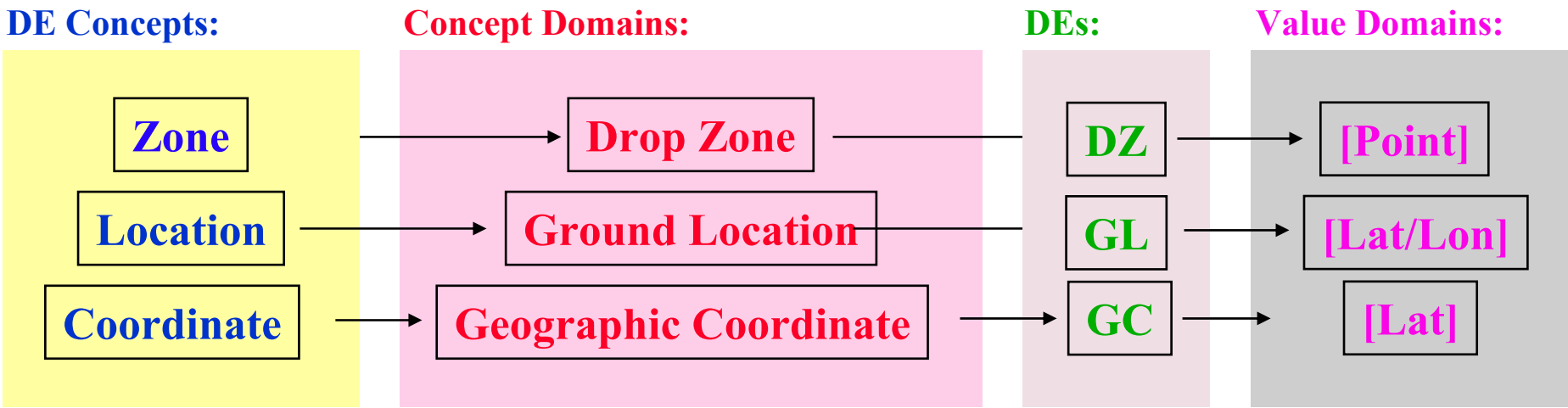
Conclusions

- **UML is a viable and robust meta-model for all Object-Oriented models**
- **UML can be represented effectively in XML**
- **The C2 domain is inherently Object-Oriented**
- **UML is a viable and robust meta-model for C2 architectures and applications**
- **C2 Applications and architectures can be represented effectively in XML**
- **C2RM is needed as viable and robust meta-model for all C2 UML models and applications and all C2 XML representations**
- **C2 metadata registries will be more effectively utilized if they are designed to correspond to a robust C2 meta-model such as the C2RM**

For More Information

Dr. Israel Mayk, CERDEC
US Army Communications-Electronics Command (CECOM),
Research, Development and Engineering Center (RDEC)
israel.mayk@us.army.mil

Inter-relating ISO 11179 Concepts and Domains



DE Concept: The Data Field / Variable, eg: Zone
Concept Domain: The Data Use / Context, eg: Drop Zone
DE: the Data Field Identifier / Name / Symbol, eg: "DZ"
Value Domain: [Point]
DE Concept: The Data Field / Variable, eg: Location
Concept Domain: The Data Use / Context, eg: Ground Location
DE: the Data Field Identifier / Name / Symbol / Label, eg: "GL"
Value Domain: [Lat/Lon]
DE Concept: The Data Field / Variable, eg: Coordinate
Concept Domain: The Data Use / Context,eg: Geographic Coordinate
DE: the Data Field Identifier / Name / Symbol, eg: "GC"
Value Domain: [Latitude]

Information Architecture for Unit Status